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POLAR CLASS ANTARCTIC 1984

ICE IMPACT TESTS

TP 7184E

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BY:

C. Daley,
R. Brown,
J. St.John,
J. Myers.

PREPARED FOR:

TRANSPORTATION DEVELOPMENT CENTRE,
Complexe Guy Favreau,
200 Dorchester Blvd. West,
Suite 601, West Tower,
Montreal, Quebec.
H2Z 1X4

PREPARED BY:

ARCTEC CANADA LIMITED,
311 Legget Drive,
Kanata, Ontario.
K2K 1Z8

PROJECT TEAM:

Arctec Canada Limited:

C. Daley,
R. Brown.

Arctec Engineering Incorporated:

J. St.John,
J. Myers.

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APPROVED BY: _____

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17. Abstract

This report presents the results of the local ice loads data collection aboard USCGC POLAR SEA in Antarctica in January 1984. The measurement system was developed for the Ship Structure Committee and the Canadian Ministry of Transport to be used in the Alaskan Arctic.

The objective of this effort was to gather data in thick level ice to be used for theoretical model validation and as a comparison with the ice pressures experienced in the Arctic. A total of 309 impacts were recorded in ice that varied in thickness from 3 to 6 ft (0.9 to 1.8 m). The impacts were well centered on the panel. Speed variation for the data was from 1 to 10.5 kts (0.5 to 5.4 m/s).

The highest single sub-panel pressures were about 600 psi (4.1 MPa) and the peak measured force was 270 LT (265 MT). These values are one-third to one-half of the levels measured in the Arctic.

Measured forces are compared with various theories with good agreement. A statistical analysis of the extremes was conducted to provide information on the type of distribution that was appropriate. A Gumbel distribution appears appropriate for much of the data. Insufficient data was acquired to predict long return periods, however.

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17. Résumé Ce rapport rend compte des résultats de la campagne de mesurage des charges localisées des glaces, effectuée dans l'Antarctique à bord du POLAR SEA, brise-glace de la garde côtière américaine, en janvier 1984. La chaîne de mesure mise en oeuvre avait été étudiée pour le compte du Ship Structure Committee des Etats-Unis et du ministère canadien des Transports, en vue d'essais au large de l'Alaska. L'objectif fixé à cette recherche était de mesurer la résistance des glaces d'épaisseur uniforme, dans le but de valider les modèles mathématiques théoriques de la rupture des glaces et de permettre des comparaisons avec les résultats obtenus dans l'Arctique. Un nombre total de 309 impacts ont été enregistrés dans une glace d'une épaisseur variant entre 3 et 6 pieds (0,9 et 1,8m), les chocs ayant agi directement sur le panneau instrumenté. Quant aux vitesses de marche correspondantes, elles ont fluctué entre 1 et 10,5 noeuds (0,5 à 5,4 m/s). La pression maximum observée sur un élément panneau a été d'environ 600 lb/po^2 (4.1 MPa) et la force maximum 270 tonnes longues, soit 265 tonnes métriques, valeurs représentant entre le tiers et la moitié des valeurs correspondantes observées dans l'Arctique.

Une bonne concordance a été constatée entre les valeurs mesurées de force et les valeurs tirées des divers modèles. Une analyse statistique des valeurs extrêmes a été faite pour savoir à quel type de distribution on aurait affaire. Les résultats ont montré que la plupart des résultats suivent une distribution de type Gumbel. Le faible nombre d'impacts observés n'a pas permis de déterminer une distribution valable pour les longues périodes de retour.

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Antarctique, critères de calcul, charge des glaces, mesurage des pressions, mesurage des forces.	Le CDT dispose d'un nombre limité d'exemplaires.

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SUMMARY

This report presents the results of the local ice loads data collection aboard USCGC POLAR SEA in Antarctica in January 1984. The ship's port bow was strain gaged to measure ice pressures over an area of roughly a frame spacing (16 in. or 41 cm) vertically and longitudinally. Sixty such areas were arranged in a six row by ten frame panel extending below the waterline. The instrumented panel allowed the measurement of the peak pressure in a single sub-panel area, determination of the contact area, measurement of the pressure distribution, and total force during an impact with ice.

The measurement system was developed for the Ship Structure Committee and the Canadian Ministry of Transport to be used in the Alaskan Arctic. The pressure data collected are used to develop ice load criteria in support of icebreaking ship design and Hull Regulations for icebreaking ships. Two previous deployments of POLAR SEA collected data in first year winter ice and both summer and winter multiyear ice in the Arctic.

The objective of this effort was to gather data in thick level ice to be used for theoretical model validation and as a comparison with the ice pressures experienced in the Arctic. The absence of pressure ridges in the landfast ice in McMurdo Sound, Antarctica offers an excellent test environment. The geometry of the uniform ice thickness there, is simple to describe analytically, so it is ideal for comparison with bending failure theoretical models.

A total of 309 impacts were recorded in ice that varied in thickness from 3 to 6 ft (0.9 to 1.8 m). The impacts were well centered on the panel. Speed variation for the data was from 1 to 10.5 kts (.5 to 5.4 m/s).

The highest single sub-panel pressures were about 600 psi (4.1 MPa) and the peak measured force was 270 LT (265 MT). These values are one-third to one-half of the levels measured in the Arctic. There was no apparent trend in peak pressure with ship speed; however, agreement between the measured force data and a dynamic force equation indicated a trend of peak force with ship speed. The equation shows a linear relationship between the non-dimensional vertical force and the fourth root of the thickness based Froude number.

A statistical analysis of the extremes of force and pressure was performed. Average pressures and total force appeared to follow a Gumbel distribution. The number of events collected is inadequate to determine a distribution that is valid for long return periods but the results indicate the type of distributions that might be used as more data are collected.

SOMMAIRE

Ce rapport rend compte des résultats de la campagne de mesurage des charges localisées de glace, effectuée dans l'Antarctique à bord du POLAR SEA, brise-glace de la garde côtière américaine, en janvier 1984. L'avant bâbord du navire ayant été équipé d'un réseau extensométrique formé de capteurs délimitant des éléments de surface d'environ 16 pouces de côté (41 cm).

On comptait un total de 60 éléments, à raison de six rangées de dix, s'étendant au-dessous de la ligne de flottaison. Ce panneau instrumenté a permis de déterminer les pressions maximums par élément de surface, la surface impactée, la distribution des pressions observées ainsi que la force totale subie lors des impacts avec les glaces.

La chaîne de mesure mise en oeuvre avait été étudiée pour le compte du Ship Structure Committee des Etats-Unis et du ministère canadien des Transports, en vue d'essais au large de l'Alaska. Les résultats de ces travaux serviront à l'élaboration de critères de résistance de la coque des navires devant naviguer dans les glaces, en vue d'en réglementer le calcul. Le POLAR SEA a déjà servi à deux essais semblables dans l'Arctique, récoltant des données sur la résistance des glaces d'hiver de première année et des glaces d'hiver et d'été de plusieurs années.

L'objectif fixé à la présente recherche était de mesurer la résistance des glaces uniformes de forte épaisseur, dans le but de valider des modèles mathématiques de rupture des glaces, d'une part, et de permettre des comparaisons avec les résultats obtenus dans l'Arctique, d'autre part. L'occasion était belle de profiter des conditions présentées dans le détroit de McMurdo dans l'Antarctique, où la banquise côtière est caractérisée par l'absence de crêtes de pression. Par sa géométrie linéaire, une glace uniforme se prête très bien à une définition analytique de ses caractéristiques, permettant la comparaison directe avec les résultats tirés des modèles basés sur la théorie de la rupture par flexion.

Un nombre total de 309 impacts ont été enregistrés dans une glace d'une épaisseur variant entre 3 et 6 pieds (0,9 et 1,8 m), les chocs ayant agi directement sur le panneau instrumenté. Quant aux vitesses correspondantes, elles ont fluctué entre 1 et 10,5 noeuds, (0,5 à 5,4 m/s).

La pression maximum observée sur un élément panneau a été d'environ 600 lb/po^2 (4,1 MPa) et la force maximum 270 tonnes longues, soit 265 tonnes métriques, valeurs représentant entre le tiers et la moitié des valeurs correspondantes observées dans l'Arctique. Aucune corrélation n'a pu être notée entre pressions maximums et vitesses de marche. Néanmoins, la concordance constatée entre les valeurs mesurées de force et celles tirées d'une équation figurant les forces dynamiques en jeu indique une corrélation entre force maximum et vitesse de marche. Cette équation met en évidence une relation linéaire entre la force verticale adimensionnelle et la racine quatrième du nombre de Froude basé sur l'épaisseur de la glace.

Enfin, une analyse statistique des valeurs extrêmes de force et de pression a été faite, montrant que les pressions moyennes et les forces totales suivent une distribution de type Gumbel. Le faible nombre d'impacts observés n'a pas permis de déterminer une distribution valable pour les longues périodes de retour, mais les résultats éclairent sur les formes de distribution auxquelles on pourrait s'attendre advenant une base de données plus abondante.

TABLE OF CONTENTS

1. INTRODUCTION.....2

2. DESCRIPTION OF THE DATA COLLECTION.....4

3. DESCRIPTION OF TEST RESULTS.....6

3.1 Overview of the Measured Data.....6
3.2 Peak Envelope Curves and Comparison with the Arctic Data...10
3.3 Comparison of Measured Vertical Force Data with Theory.....14
3.4 Pressure and Contact Area Variation with Time.....16
3.5 Statistical Analysis of the Results.....18

4. CONCLUSIONS AND RECOMMENDATIONS.....21

5. REFERENCES.....22

APPENDIX A - SUMMARY OF MEASURED DATA RANKED BY SINGLE SUB-PANEL PRESSURE

APPENDIX B - SUMMARY OF MEASURED DATA RANKED TO TOTAL PANEL FORCE

APPENDIX C - THE FIVE EVENTS OF HIGHEST SINGLE SUB-PANEL PRESSURE

APPENDIX D - THE FIVE EVENTS OF HIGHEST PANEL FORCE

APPENDIX E - THREE EVENTS SHOWING THE TIME VARIATION OF PEAK AND AVERAGE PRESSURE AND CONTACT AREA

LIST OF FIGURES

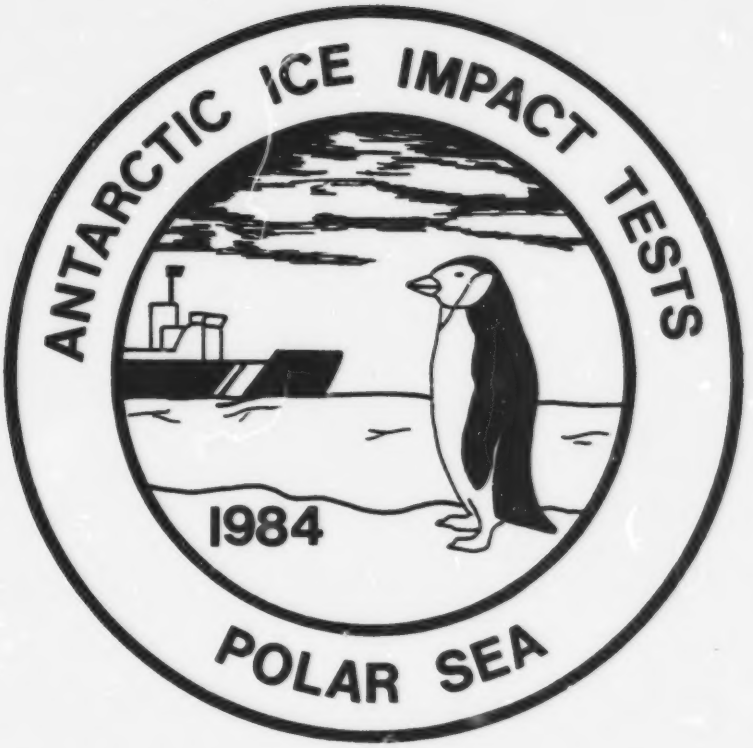
1 STRAIN GAGE LOCATIONS FOR INSTRUMENTED BOW PANEL ABOARD POLAR SEA....3
2 AVERAGE ICE THICKNESS FROM ICE EDGE TO HUT POINT....5
3 SIZE OF CONTACT AREA VERSUS ICE TYPE....7
4 PEAK PRESSURE AND PEAK FORCE VS. SHIP SPEED....9
5 ENVELOPE CURVE FOR ANTARCTIC IMPACTS....11
6 COMPARISON OF EXTREME ENVELOPE PRESSURE-AREA CURVE WITH THOSE OBTAINED IN THE ARCTIC....12
7 COMPARISON OF PEAK ENVELOPE OF PRESSURE VS. GIRTH ALONG THE FRAME WITH DATA COLLECTED IN THE ARCTIC....13
8 COMPARISON OF PEAK ENVELOPE OF PRESSURE VS. LENGTH ALONG THE WATERLINE WITH DATA COLLECTED IN THE ARCTIC....13
9 COMPARISON OF MEASURED DATA WITH VARIOUS THEORIES....15
10 PEAK AND AVERAGE PRESSURE TIME-HISTORY DURING AN IMPACT....17
11 CONTACT AREA TIME-HISTORY DURING AN IMPACT....17
12 GUMBEL EXTREME VALUE STATISTICS FOR TOTAL ICE FORCE....19
13 LOG-EXTREME VALUE STATISTICS FOR TOTAL ICE FORCE....19
14 GUMBEL EXTREME VALUE STATISTICS FOR HIGHEST AVERAGE PRESSURE..20
15 LOG-EXTREME VALUE STATISTICS FOR HIGHEST AVERAGE PRESSURE....20

LIST OF TABLES

1 FREQUENCY OF IMPACTS VERSUS HIGHEST AVERAGE PRESSURE FOR ANTARCTIC IMPACTS....7
2 FREQUENCY OF IMPACTS VERSUS LOCATION AT TIME OF PEAK PRESSURE....8
3 FREQUENCY OF IMPACTS VERSUS LOCATION AT TIME OF PEAK FORCE....8

NOMENCLATURE

a	regressed exponent
C	constant
F_D	peak dynamic force
F_{TS}	total static load
g	acceleration due to gravity
h	ice thickness
ksi	thousands of psi
LT	long tonnes
m/s	metres per second
MT	metric tonnes
MPa	mega pascals
psi	pounds per inch
V_s	ship's velocity
V_v	vertical velocity
σ_f	flexural strength
γ	buttock angle


ANTARCTIC ICE IMPACT TESTS
1984
POLAR SEA

1. INTRODUCTION

This report summarizes the local ice loads measurement conducted in McMurdo Sound, Antarctica between January 9 through January 13, 1984. The data were collected during Deep Freeze 1984, the deployment of USCGC POLAR SEA to open the station at McMurdo Sound for resupply by sea.

An instrumented bow panel on the icebreaker's port bow was used to gather the ice loads. Ten cant frames (CF 35 to CF 44) were instrumented at 8 vertical locations by strain gaging the webs of the frame in compression perpendicular to the shell plating. A total of sixty active channels of strain gages allowed contact pressures over an area up to 98 ft^2 (9.1 m) to be measured. An individual strain gage channel was related to an area of 1.63 ft^2 (.15 m) for which a uniform pressure was computed for a measured strain. Each area associated with a strain gage channel is termed a sub-panel and the collection of all sixty sub-panels is termed the measurement panel. A complete description of the data acquisition system, the data reduction procedures, and previous data collection efforts in the Arctic can be found in Reference 1.

The meaurement system used in this project was developed for the Ship Structure Committee and the Canadian Ministry of Transport for the measurement of ice pressures in the Arctic. The system was used on two previous deployments of POLAR SEA in the Alaskan Arctic [1]. The impetus for this current data collection effort was to measure ice loads in thick level ice; ice conditions that can be readily characterized to provide a data base for comparison with analytical models of ice/structure interaction. A comparison of Arctic and Antarctic ice contact pressures is also of interest to the U.S. Coast Guard. This project was jointly funded by the U.S. Coast Guard, the U.S. Maritime Administration, and the Canadian Ministry of Transport.

The measurement system used in this project was developed for the Ship Structure Committee and the Canadian Ministry of Transport for the measurement of ice pressures in the Arctic. The system was used on two previous deployments of the POLAR SEA in the Alaskan Arctic [1]. The impetus for this current data collection effort was to measure ice loads in thick level ice; ice conditions that can be readily characterized to provide a data base for comparison with analytical models of ice/structure interaction. A comparison of Arctic and Antarctic ice contact pressures is also of interest to the U.S. Coast Guard. The project was jointly funded by the U.S. Coast Guard, the U.S. Maritime Administration, and Canadian Ministry of Transport.

The results of level ice resistance tests are reported in "Polar Class Antarctic 1984 - Level Ice Resistance Tests", TP7183E, [8].

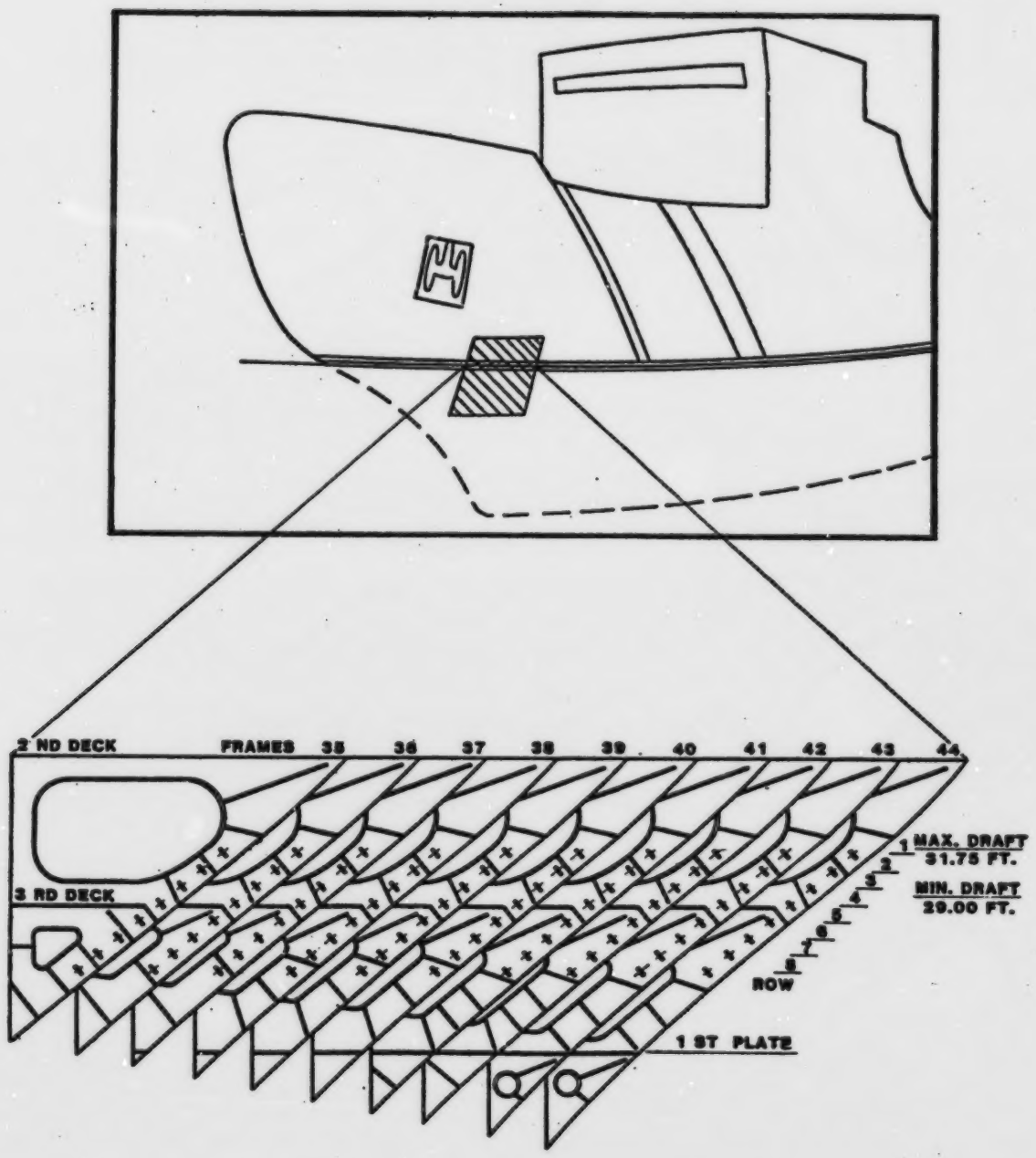


Figure 1

STRAIN GAGE LOCATIONS FOR INSTRUMENTED BOW PANEL ABOARD POLAR SEA

2.0 DESCRIPTION OF THE DATA COLLECTION

As previously stated, data were collected during "break-in" operations to open the sea lane into McMurdo Station. Operations were conducted in land-fast first year ice which varied from about 3 feet (.9m) thick at the ice edge to 6 feet (1.8 m) feet thick near the Station. The extent of the ice was approximately 18 miles from the ice edge to the Station.

Instrumentation was installed in Seattle before the ship sailed. The test team was flown to and from McMurdo for the five days of testing which occurred in January during the break-in operation. The ice loads data collection was conducted simultaneously with level ice resistance tests (reported in [2]). Large areas of the ice were drilled at regular intervals and their thickness documented by colored flags placed next to the drilled holes. When the ship transitted the areas, the ice thickness could be recorded concurrently with ice resistance and ice pressure data. After the dedicated tests, the ship engaged in "scarfing" operations where the ship widened a previously broken channel. Ice pressure data were recorded during the scarfing operations as well.

Approximately 1000 five second events (where significant strains were measured) were recorded during the five days. Unfortunately, when the test team arrived onboard, the ship was operating in a light condition (minimum draft) with trim by the stern. Initial impacts showed that the ice pressures were occurring largely below the panel. Efforts were made to ballast the ship down by the bow but this operation could not be completed before the dedicated tests were completed. A total of 309 events were recorded after the ballasting operation and these are the data that have been reduced. Ice thickness was not recorded for these events, however, the ice thickness for the data was between 3 and 6 feet (.9 and 1.8 m). The 309 events show good centering of the impacts on the panel and a wide speed range from 1 to 10.4 knots. These are the data collected during scarfing so it is assumed that most of the data results from single-sided impacts.

In analyzing the data, a problem was identified with the manner in which the data were collected. Due to the very limited manpower, zeroes were not taken as often as in previous deployments. This meant that channel drift was not removed from the measured data at source and, since the drift was larger and the peak strains lower than in the Arctic, the drift significantly affected the measurement. Drift was easily removed from the signal at the data reduction and analysis' stage by zeroing each channel, however, each channel had to be viewed individually to determine the time interval over which averages should be taken to determine the true zero. The large number of channels, sixty channels for each of the 309 events, meant that data reduction time was greatly increased. As a result, however an excellent data set was achieved since each strain channel was scrutinized individually.

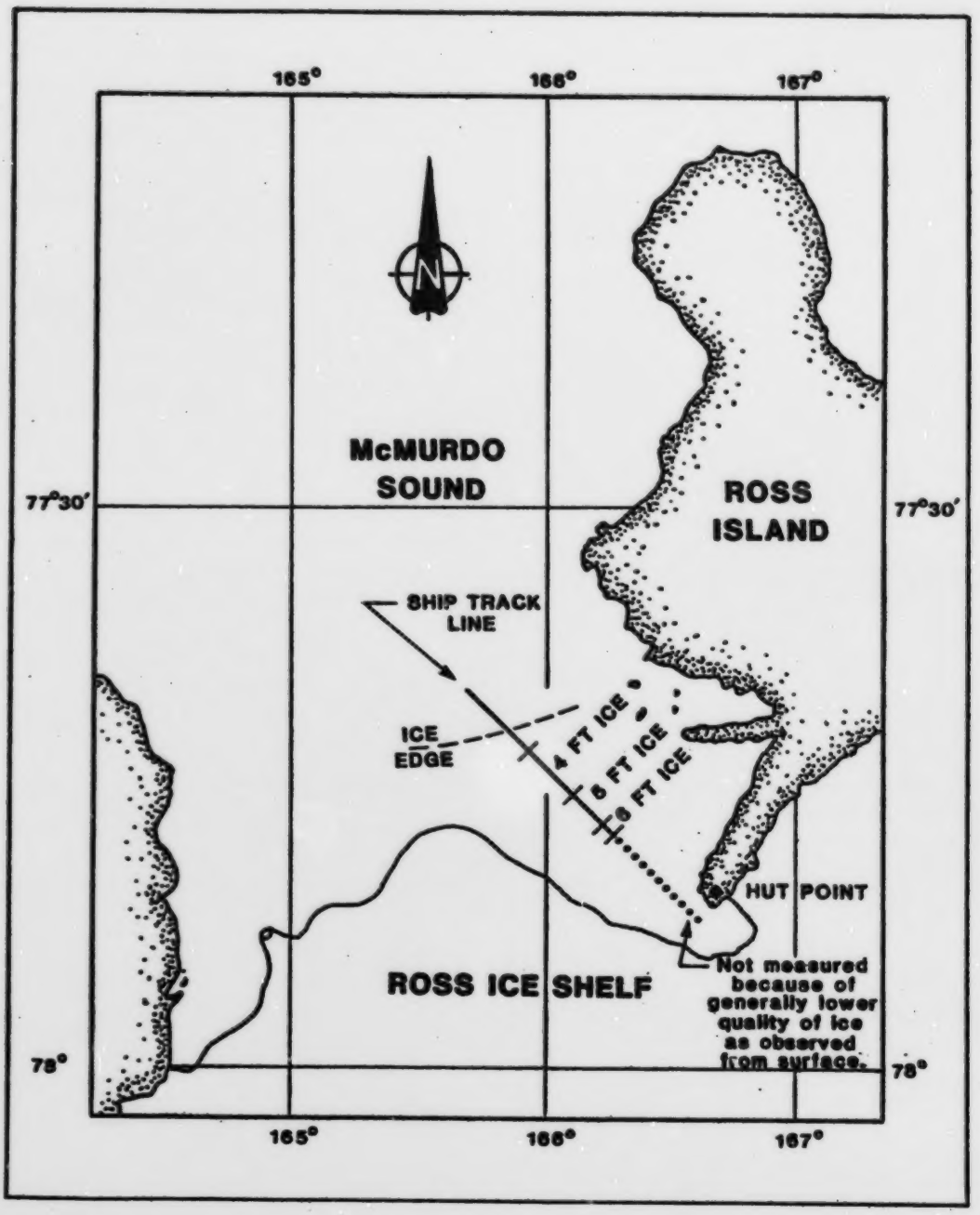


Figure 2

AVERAGE ICE THICKNESS FROM ICE EDGE TO HUT POINT

3. DESCRIPTION OF TEST RESULTS

3.1 Overview of the Measured Data

Of the 309 events that were analyzed, the data appear to be of excellent quality; that is, impacts are well centered on the panel and cover a wide range of speed. Additionally, channels that developed ground leaks or failed during the tests were not in critical areas of the panel where most of the impacts were occurring.

Table 1 shows the frequency of impacts versus highest average pressure for different contact areas. It is somewhat surprising that the contact areas are so large for bending failure. Approximately 18% of the impacts had contact areas of at least 50 ft^2 (2.3 m^2). Figure 3 compares the distribution of impacts by area in the thick level ice with that in the multi-year Arctic ice [1]. It is also significant to note that the frequency distribution of pressure on a single sub-panel does not slowly decrease with increasing pressure as seen in the Arctic data. Ten events were recorded in the range of 550 to 600 psi (3.8 to 4.0 MPa) and no events above that range. This is presumably because of the absence of a pure crushing type failure.

Tables 2 and 3 show the number of peak pressures and peak forces, respectively, that were recorded at each location. These tables show that the data were well centered vertically on the panel and evenly distributed longitudinally.

Figures 4(a) and (b) show the peak pressures and peak forces plotted versus ship speed. Impacts were recorded at ship speeds of 1 to 10.5 kts (.5 to 5.4 m/s) with the bulk of the data recorded between 6 and 8.5 kts (3.1 and 4.4 m/s). There is no apparent relationship between peak force or pressure and speed, however, some increase in peak force with speed is indicated by the data when compared to theory in Section 4.3.

TABLE 1 FREQUENCY OF IMPACTS VERSUS HIGHEST AVERAGE PRESSURE FOR ANTARCTIC IMPACTS

PRESSURE (psi)	NUMBER OF SUB-PANELS 1	6	15	31	46	60
0-50	0	1	48	43	3	0
50-100	0	86	199	14	0	0
100-150	1	175	13	0	0	0
150-200	20	42	0	0	0	0
200-250	57	3	0	0	0	0
250-300	70	0	0	0	0	0
300-350	68	0	0	0	0	0
350-400	46	0	0	0	0	0
400-450	21	0	0	0	0	0
450-500	11	0	0	0	0	0
500-550	5	0	0	0	0	0
550-600	10	0	0	0	0	0
TOTALS	309	307	260	57	3	0

NUMBER OF SUB-PANELS	AREA FT^2	AREA M^2
1	1.63	0.15
6	9.79	0.91
15	24.5	2.28
31	50.6	4.70
46	75.1	6.98
60	97.9	9.10

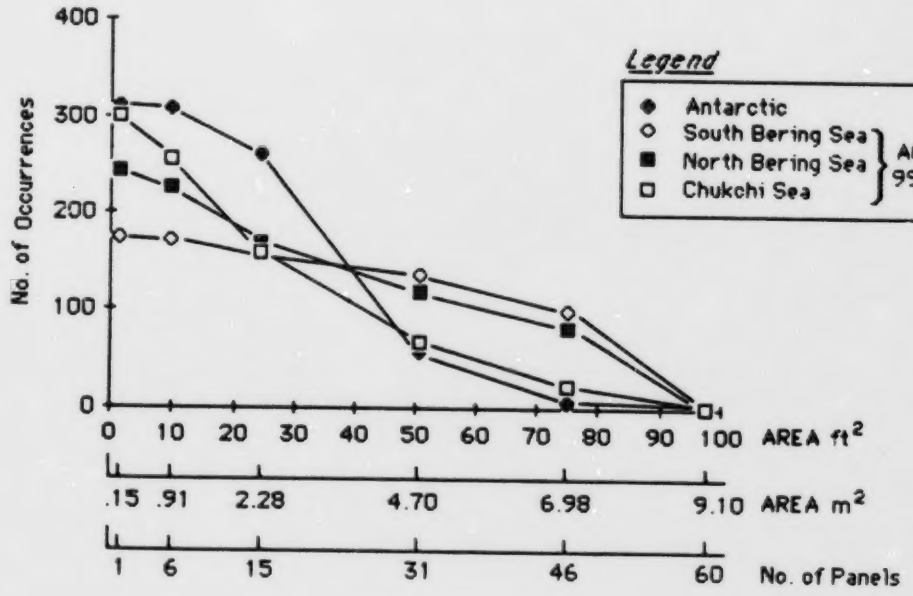


Figure 3

SIZE of CONTACT AREA VERSUS ICE TYPE

TABLE 2 FREQUENCY OF IMPACTS VERSUS LOCATION AT TIME OF PEAK PRESSURE

ROW	FRAME NUMBERS 44	43	42	41	40	39	38	37	36	35
3	0	0	2	0	0	0	1	0	0	0
4	1	1	0	2	0	1	0	0	0	0
5	5	6	1	6	4	0	5	18	3	15
6	9	5	9	12	0	4	10	7	23	1
7	4	2	4	26	0	10	0	30	23	28
8	2	1	6	2	1	10	6	2	2	0

TABLE 3 FREQUENCY OF IMPACTS VERSUS LOCATION AT TIME OF PEAK FORCE

ROW	FRAME NUMBERS 44	43	42	41	40	39	38	37	36	35
3	0	0	1	0	0	0	1	0	0	0
4	3	4	0	3	0	1	1	0	0	0
5	6	13	7	8	9	2	11	15	2	2
6	2	4	10	11	1	8	11	11	13	2
7	5	5	2	24	3	12	5	29	15	9
8	0	2	2	6	5	7	14	0	3	0

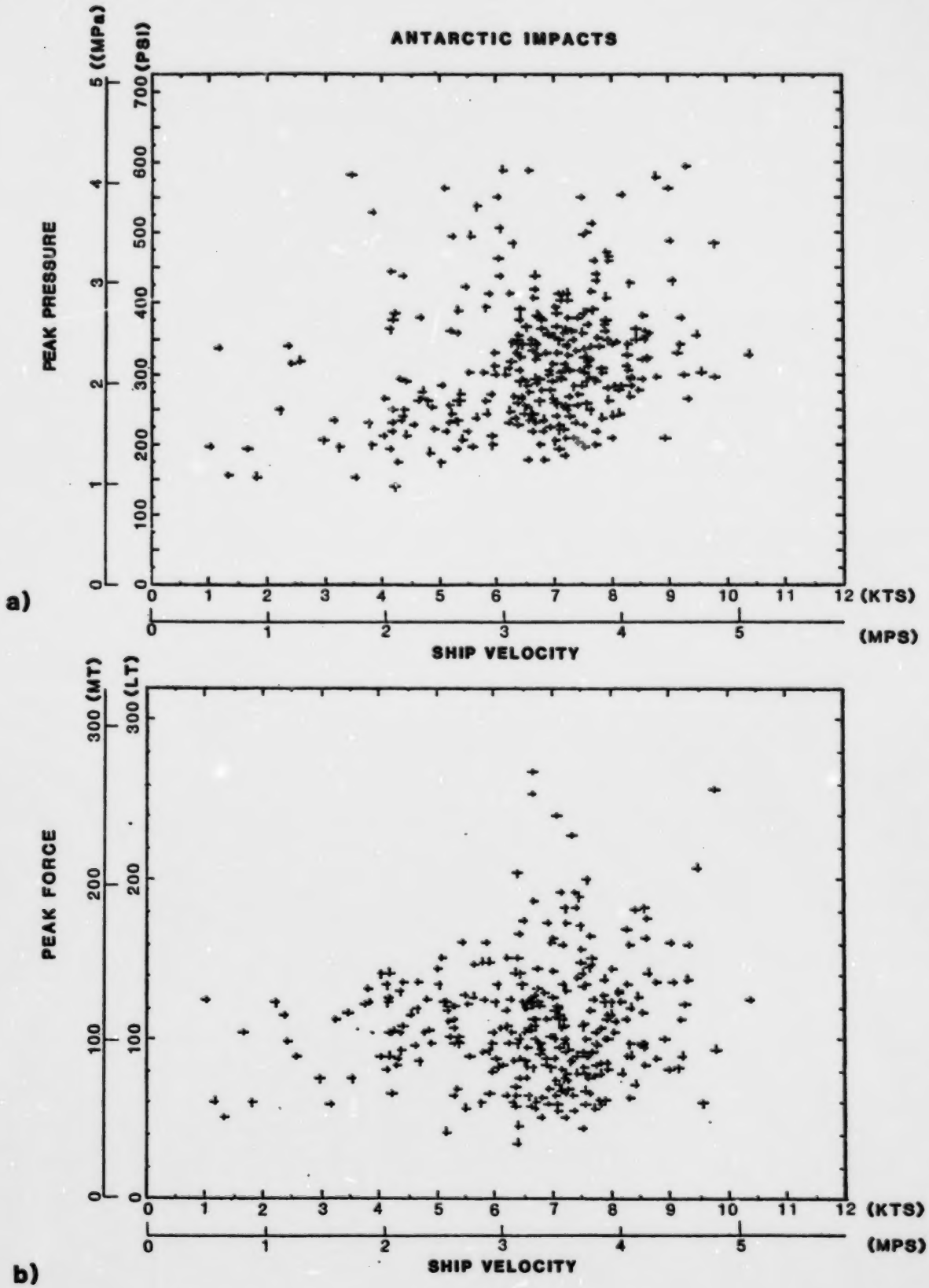


Figure 4

PEAK PRESSURE AND PEAK FORCE vs. SHIP SPEED

3.2 Peak Envelope Curves and Comparison with the Arctic Data

The highest average pressure recorded for each area for all of the 309 events is shown in Figure 5. It is interesting to note that for this envelope curve of the data, the highest average pressure decreases linearly to an area of about 30 ft^2 ($2.8m^2$) and then follows a line of constant force for larger areas (a 45° line of decreasing slope is a line of constant force on log-log pressure area plot).

Figure 6 compares the pressure area envelope curves recorded in the Arctic on the 1983 Winter Deployment to the curve of Figure 5. One can see that the pressure experienced in Antarctica is considerably less than the Arctic data for areas less than 30 ft^2 ($2.8m^2$), but above that area, the pressures encountered in Antarctica are equivalent to the Bering Sea. The higher pressures in the Arctic presumably are caused by the ridges in which larger areas of contact are developed in crushing, creating higher small area pressures due to local confinement of the ice. The number of impacts recorded for each data set was roughly equivalent.

Figures 7 and 8 present the highest average pressures in a slightly different format. The designer would be interested in the highest average pressure as a function of stringer or frame span. The data presented in these curves attempts to accommodate this view. The curves presented are the envelope of highest average pressures in a line vertically and longitudinally along the shell plating. Again, the Antarctica data are lower than the Arctic data for short spans and equivalent to Bering Sea data for longer spans.

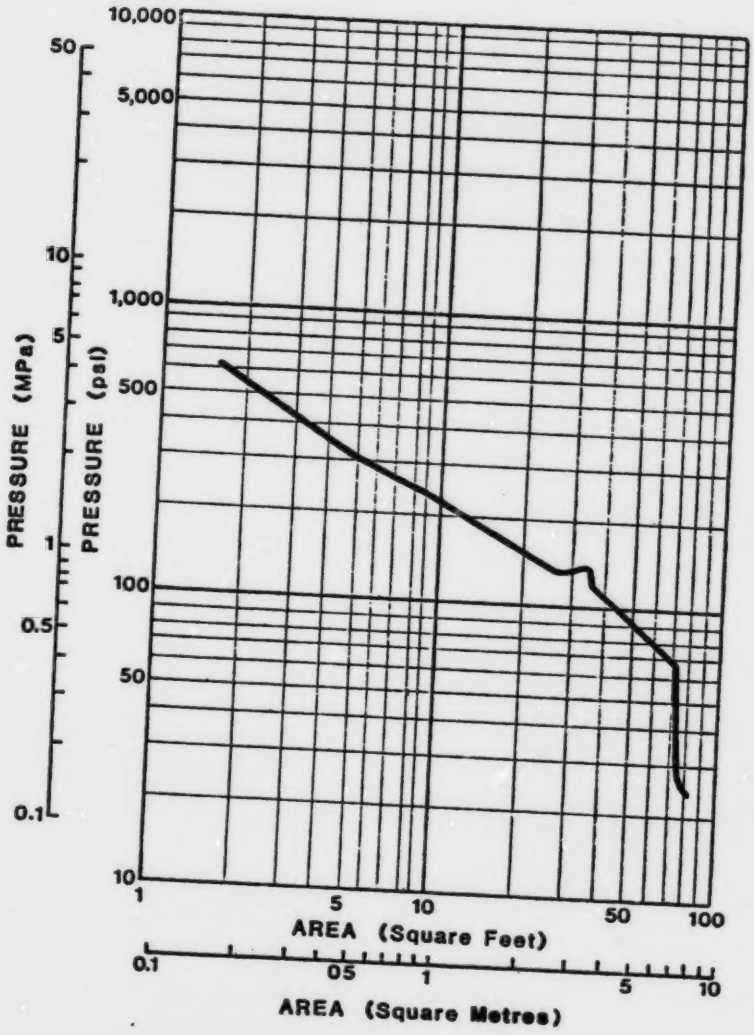


Figure 5
ENVELOPE CURVE FOR ANTARCTIC IMPACTS

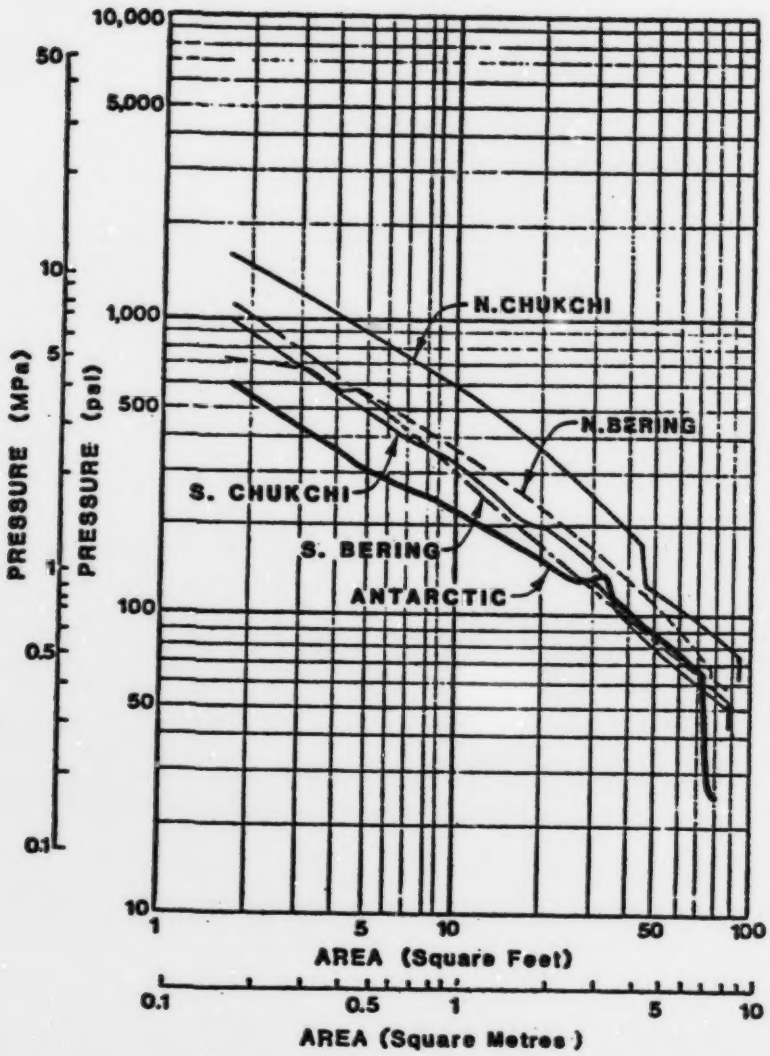


Figure 6

COMPARISON OF EXTREME ENVELOPE PRESSURE-AREA CURVE WITH THOSE OBTAINED IN THE ARCTIC

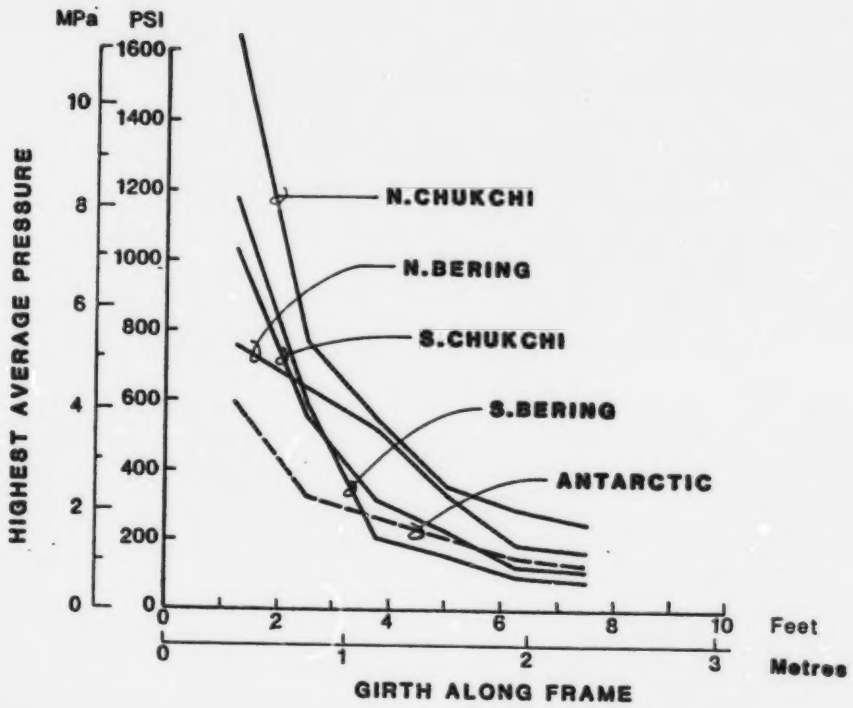


Figure 7

COMPARISON OF PEAK ENVELOPE OF PRESSURE vs. GIRTH ALONG THE FRAME WITH DATA COLLECTED IN THE ARCTIC

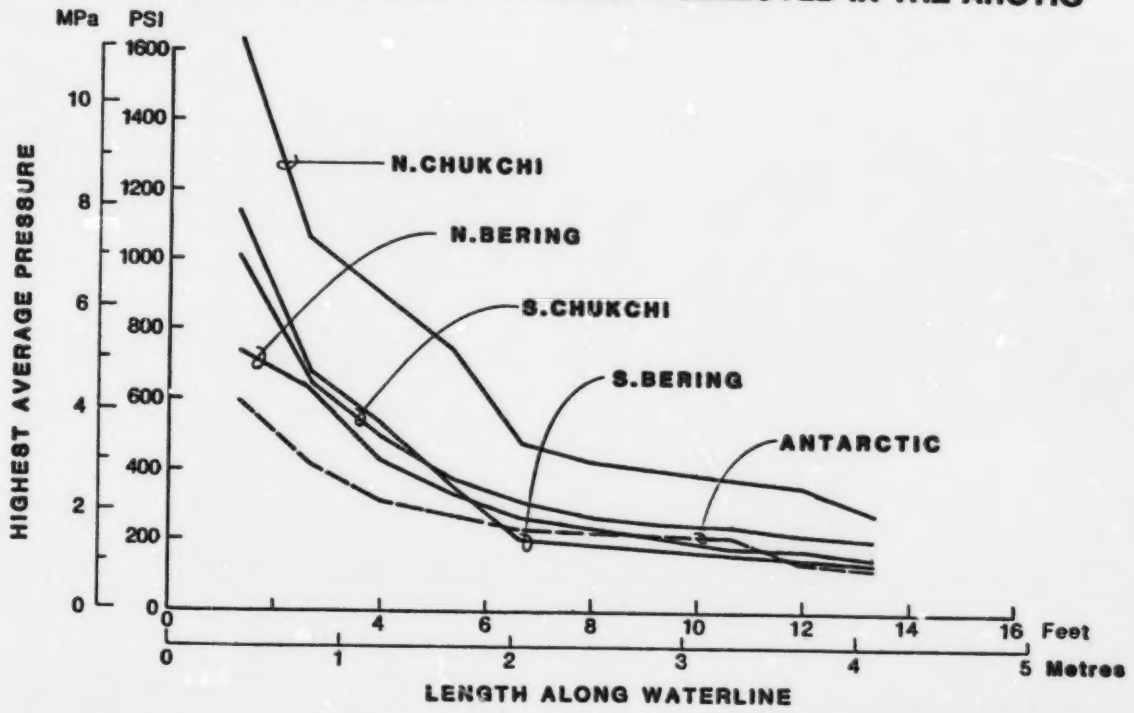


Figure 8

COMPARISON OF PEAK ENVELOPE OF PRESSURE vs. LENGTH ALONG THE WATERLINE WITH DATA COLLECTED IN THE ARCTIC

3.3 Comparison of Measured Vertical Force Data with Theory

Measured data were compared with the static theory of cusp breaking of Nevel [3] which examines the vertical force to break a semi-infinite level ice sheet. The peak vertical force (when the radial crack is formed) is a function of the loading width and length as well as the ice thickness, flexural strength, and characteristic length of the ice sheet. Flexural strength was estimated to be 44 psi (.3 MPa) from measured temperature and salinity profiles taken in the area using Vaudrey's equation [4] and reported in Appendix I of [8]. Elastic modulus was estimated to be 90 ksi (620 MPa) in a similar manner. Characteristic lengths of 26.8 and and 45 ft (8.2 and 13.7 m) were computed for ice thicknesses of 3 and 6 ft (0.9 and 1.8 m) respectively, the range of ice thickness in the area. The static vertical load was computed from Nevel's theory using the actual dimensions of the vertical projection of the impact area at the time of peak force for each event. The calculations fell within a narrow band of forces, 29 LT (28.5 MT) for the highest event at 6 ft (1.8 m) thickness and 5 LT (4.9 MT) for the lowest event at 3 ft (0.9 m) thickness. This band is superimposed on the actual measured forces in Figure 9. If a peak theoretical force of 29 LT (28.5 MT) is used, the ratio of measured or dynamic force to theoretical or static force can be seen to be as much as 5.45. Comparison of the averages of both the measured and theoretical data shows a ratio of about 4.

Kerr [5] has developed an equation for prediction of the static total load given as:

$$F_{TS} = 0.518\ \sigma_f\ h^2$$

where F_{TS} is the total static load for a bending failure, σ_f is the ice flexural strength, and h is the ice thickness.

This theory differs from that of Nevel in the fact that Nevel treats only the formation of the first crack and when total failure is considered, the peak force is somewhat higher. The range of total static load for ice thicknesses between 3 and 6 ft (.9 and 1.8 m) is shown in Figure 9 for the computed ice strength.

Also shown are curves of dynamic force for various ice thicknesses developed by Daley [6] and based on a finite element analysis of thin ice by Varsta [7]. The equation for dynamic force is given as:

$$F_D = 1.05\ \sigma_f\ h^{1.875}\ V_V^{.25}$$

where F_D is the peak dynamic force (in MN) in a bending failure considering only the first vibrational mode of the ice sheet, h is the ice thickness (in m), σ_f is the flexural strength (in MPa), and V_V is the vertical velocity (in MPS) given as a function of the ship's velocity (V_S) in the following formula:

$$V_V = \frac{V_S}{\tan \gamma}$$

where γ is the local buttock angle measured from the vertical plane. The local buttock angle is 67.5° for the measurement panel.

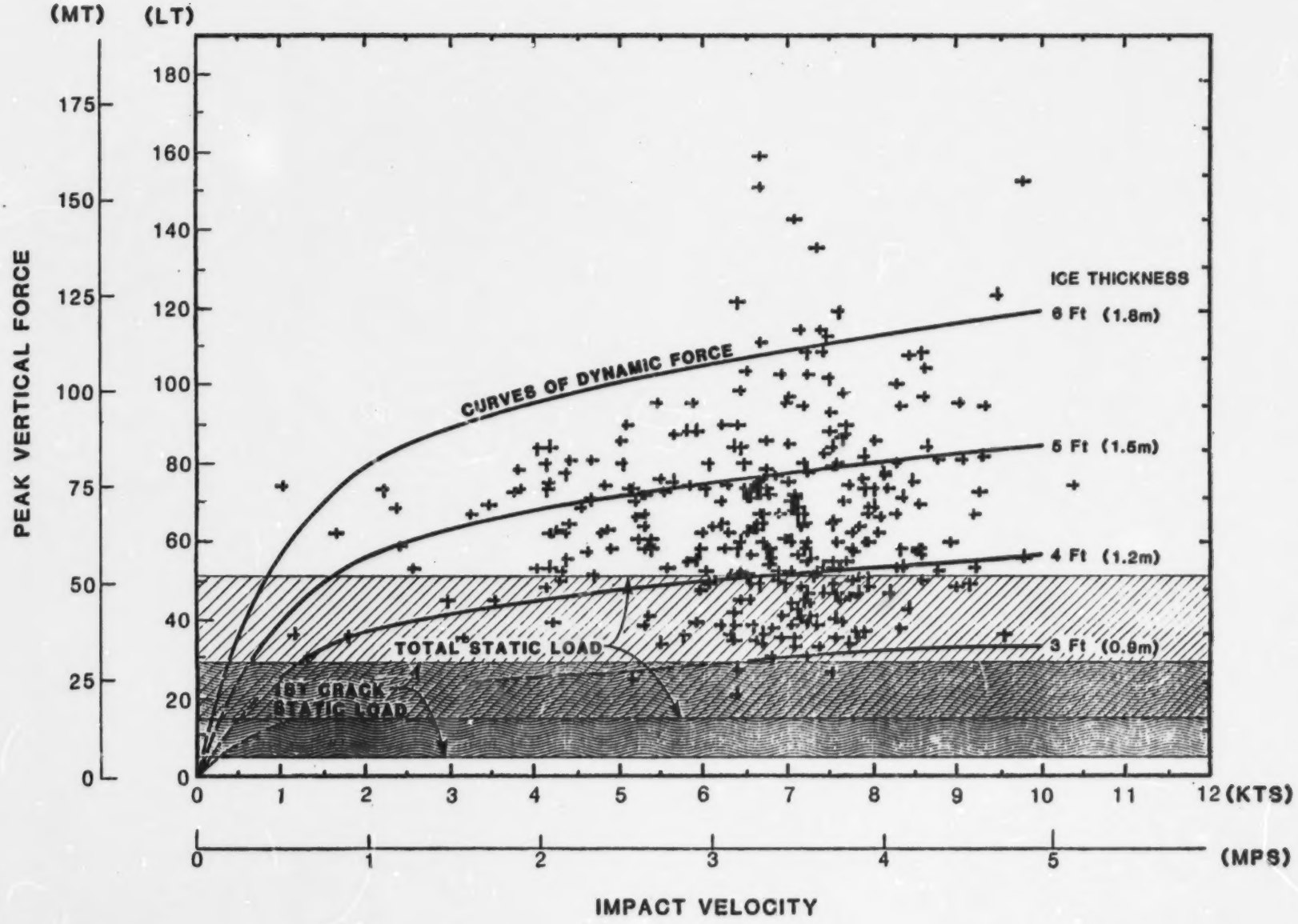


Figure 9 **COMPARISON OF MEASURED DATA WITH VARIOUS THEORIES**

The dynamic force equation bounds the measured data. The 3 and 6 ft curves (.9 and 1.8 m) bound almost all of the data. Extremes of vertical force above the 6 ft (1.8 m) curve could be attributable to thicker ice or, since they occur in localized speed ranges, to contributions from higher modes not reflected in the theory to develop the dynamic force equation. It is interesting to note that the dynamic force equation can be written in non-dimensional terms as:

$$\frac{F_D}{\sigma_f h^2} = C \left(\frac{V_v}{\sqrt{g\ h}}\right)^{1/4}$$

where C is a constant and g is the acceleration due to gravity. It would be interesting to reformulate Varsta's data in the form:

$$\frac{F_{TOT}}{\sigma_f h^2} = C_1 + C_2 \left(\frac{V_v}{\sqrt{g\ h}}\right)^a$$

where C_1 and C_2 are contants, a is the regressed exponent, and C_1 is taken as .518 form Kerr's work for total static load. The result would be an equation for dynamic force that is both non-dimensional and converges to the static load with decreasing velocity.

3.4 Pressure and Contact Area Variation with Time

Three significant events were analyzed in more detail to demonstrate how the peak and average pressure and the contact area varied with time during the impact. The results for one of these events are shown in Figures 10 and 11. For this particular event, the contact area increased in an almost linear fashion (with some oscillations) until bending failure of the sheet caused sufficient movement of the broken cusp to unload the sheet.

In the initial stages of the impact, both peak and average pressure as well as contact area were increased indicating confinement effects were occurring. The peak force was reached just after the time of highest average pressure on the panel (time step 32, Figure 10). Shortly thereafter, the peak pressure on the single sub-panel was reached (time step 34, Figure 10). There was a relatively gradual decrease in pressure (relative to the rise) from the peak. The contact area was increasing throughout until the ice piece abruptly lost contact (time step 48, figure 11).

Appendix E contains complete documentation of this and the other two events. Confinement effects are prevalent in all the impacts examined. Typically, the peaks of single sub-panel pressure, panel average pressure, and total panel force occur at close to the same time early in the event. Contact area increases throughout the event and peaks near the end of the event. These effects were seen in the Arctic data as well, however, the impacts were of much longer duration.

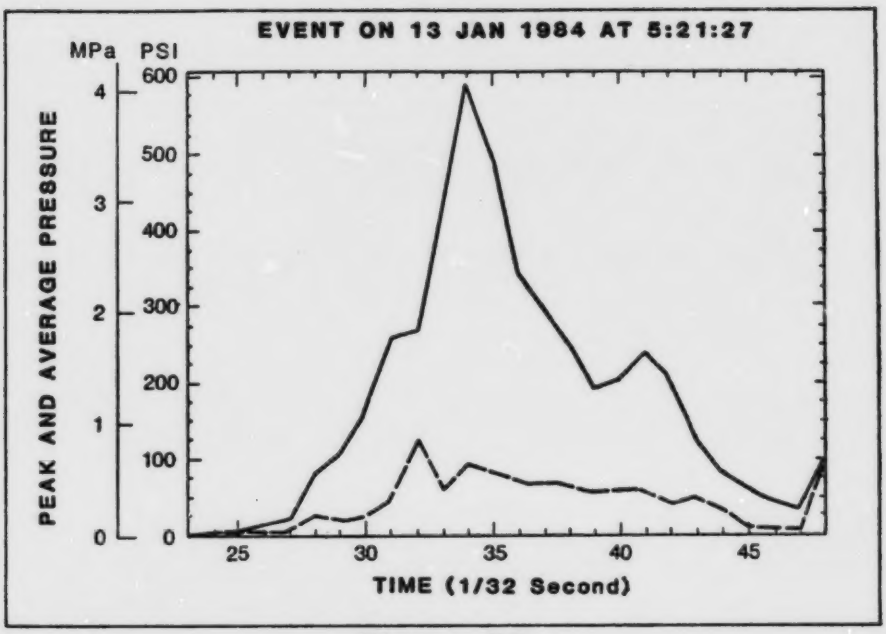


Figure 10

PEAK AND AVERAGE PRESSURE TIME-HISTORY DURING AN IMPACT

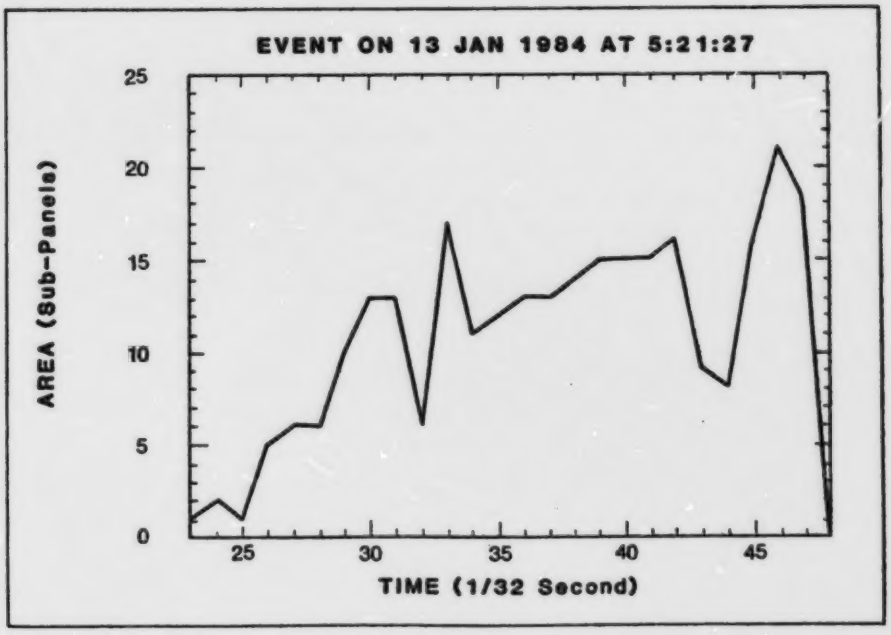


Figure 11

CONTACT AREA TIME-HISTORY DURING AN IMPACT

3.5 Statistical Analysis of the Results

The 309 impacts were rank ordered by highest total panel force (Appendix B) and secondly, by highest single sub-panel pressure (Appendix A). A probability of occurrence was computed for each ranking as the reciprocal of one plus the order number. One minus the probability of occurrence is the probability of non-occurrence or the probability that, given an impact, the pressure will be less than the force or pressure value.

Both the force and pressure data were plotted on Gumbel and log-extreme value paper to examine the trend in the extremes of the data. The force data are presented in Figure 12 using a Gumbel type plot and in Figure 13 using a log-extreme value type plot. Figure 12 shows the data are extremely linear over the entire range with the exception of the highest four points. The Log-Extreme value curve also is quite linear above the mean of the data (Figure 13). The uppermost points in the log-extreme value distribution fall closer to a line through the data than with the Gumbel distribution; however, less emphasis should be given to the last few points since the likelihood of a deviation from the distribution increases as the extremes of the data are approached. If one considers that because of the threshold all the data collected are the extremes of a much larger data set, the Gumbel appears to be the better fit to the data. It is important to note, however, that 309 events are a small amount of data to evaluate an extreme value distribution and much more data would be necessary to confirm the type of distribution.

Figures 14 and 15 present the data for the highest pressure for various numbers of sub-panels (areas) plotted on Gumbel and log-extreme value probability paper. With the exception of the single sub-panel pressures, both distributions appear quite linear at the upper end of the curves. The Gumbel distribution fits the data somewhat better, however. One would expect that the pressure for higher areas would follow the distribution for total force since the pressure area curves approach lines of constant force at high contact area.

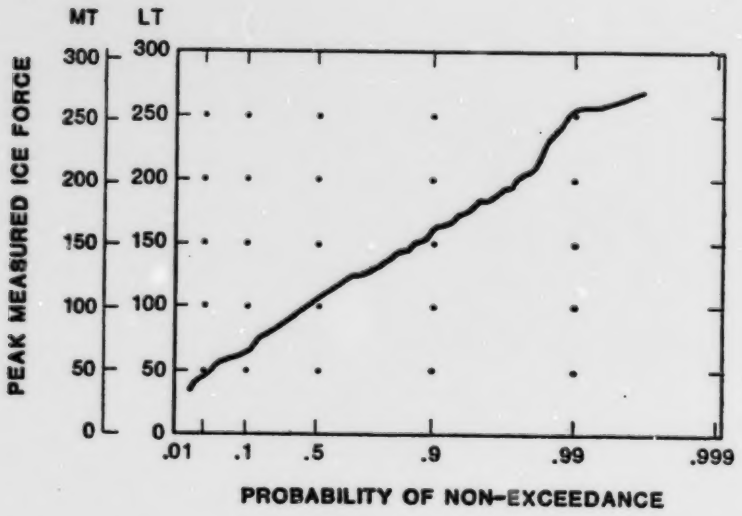


Figure 12

GUMBEL EXTREME VALUE STATISTICS FOR TOTAL ICE FORCE

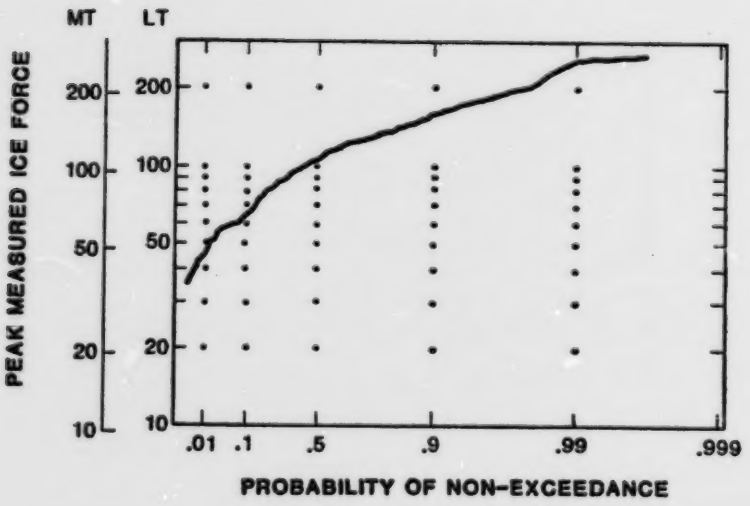


Figure 13

LOG-EXTREME VALUE STATISTICS FOR TOTAL ICE FORCE

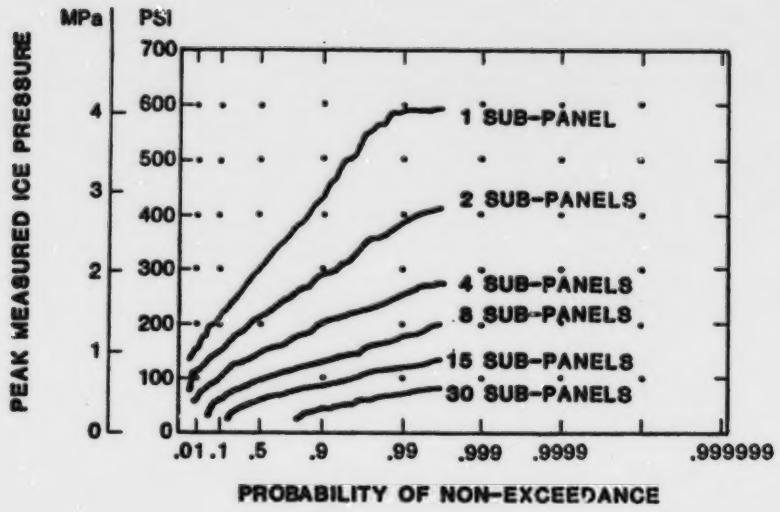


Figure 14

GUMBEL EXTREME VALUE STATISTICS FOR HIGHEST AVERAGE PRESSURE

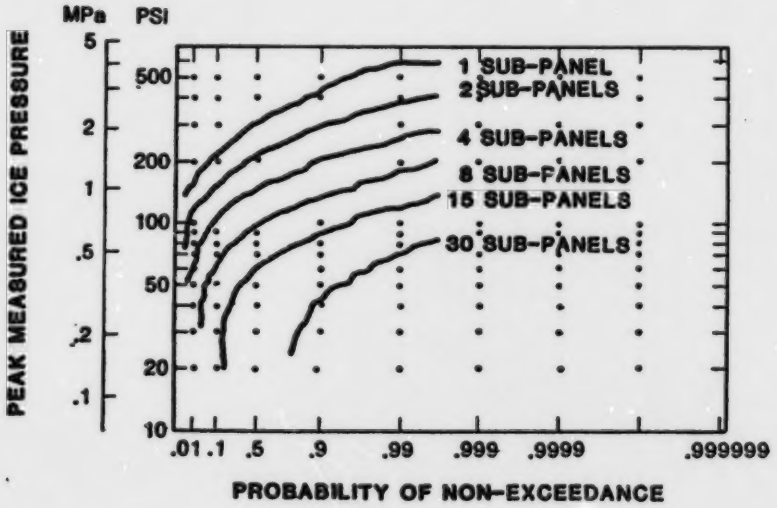


Figure 15

LOG-EXTREME VALUE STATISTICS FOR HIGHEST AVERAGE PRESSURE

4.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions from the study are as follows:

1. The envelope of the data showed single sub-panel pressures (areas of 1.6 ft^2 or .15 m^2) of less than 600 psi (4.1 MPa) and total panel forces less than 270 LT (265 MT). These pressures and force are less by a factor of 2 to 3 than those recorded in the Arctic.

2. Speed effects were not apparent in the single sub-panel pressure or total force data, however, see 3 below.

3. There appears to be good agreement between the vertical force prediction equation proposed by Daley [6]:

$$F_D = 1.05\ \sigma_f\ t^{1.875}\ V_v^{.25}$$

and the measured data. The equation appears to bracket the majority of the measured data.

4. Total force and pressure data fit a Gumbel probability distribution for the limited number of events collected (309 events).

5. Single sub-panel pressures do not follow the distribution as well as the average pressures over larger areas or the total force.

Recommendations for future work include the collection of additional level ice data where individual events have documented ice thickness. Since it was not possible to document the ice thickness for the events recorded on this deployment, comparison with theory is difficult since thickness is the dominant variable in bending failure modes.

It is strongly recommended therefore that greater emphasis be placed in the future on ensuring a commitment of time for the ship, and provision of adequate labour to guarantee well documented ice conditions. Much more data is needed to verify the type of statistical extreme value distribution for bending failure and to confidently use such a distribution for loads prediction for design. The lower levels of loading in Antarctica make data acquisition of local ice pressures more difficult and adequate resources must be provided in future programs to adjust thermal drift through frequent zeroing.

Additionally, it is recommended that additional theoretical models be developed to compare with measured data. These models should treat the ship speed effects to compute peak dynamic force as a function of ice thickness and strength.

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6. Daley, C., "Group Four Study, Final Report", prepared for Transport Canada, Coast Guard Northern, ARCTEC CANADA Report No. 1718C.

7. Varsta, P., "On the Mechanics of Ice Loads on Ships in Level Ice in the Baltic Sea", TRC of Finland, Pub. 11, 12SP00, 1983.

8. "Polar Class Antarctic 1984 - Level Ice Resistance Tests", prepared for Transportation Development Centre, TP7183E, March 1985.

APPENDIX A

SUMMARY OF MEASURED DATA RANKED BY SINGLE SUB-PANEL PRESSURE

KEY:

- PM1 - Maximum single sub-panel pressure (psi)
- PA1 - Average pressure over the contact area at the time of peak pressure (psi)
- A1 - Contact area at the time of peak pressure (sub-panels)
- F1 - Total panel force at the time of peak pressure (LT)
- PM2 - Maximum single sub-panel force (psi)
- PA2 - Average pressure over the contact area at the time of peak force (psi)
- A2 - Contact area at the time of peak force (sub-panels)
- F2 - Peak total panel force (LT)
- VEL - Ship velocity at impact

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 JAN 1984	17:30:54	139	70	7	51	119	45	14	66	4.2
12 JAN 1984	17:26:9	152	41	7	30	123	42	17	75	3.5
12 JAN 1984	16:52:25	154	42	13	57	131	44	13	60	1.8
12 JAN 1984	16:51:48	155	56	8	47	143	81	6	51	1.3
12 JAN 1984	16:33:9	173	32	42	141	164	32	43	144	5.0
12 JAN 1984	17:27:12	175	63	16	106	175	63	16	106	4.3
12 JAN 1984	17:28:38	177	42	14	62	77	26	23	63	6.8
12 JAN 1984	16:45:1	178	22	33	76	178	22	33	76	6.5
12 JAN 1984	16:27:44	184	45	15	71	171	49	26	134	7.2
12 JAN 1984	17:31:53	188	61	13	83	128	52	23	125	4.8
12 JAN 1984	17:24:44	193	27	26	74	165	47	21	104	1.7
12 JAN 1984	17:28:47	193	28	15	44	132	63	9	59	7.1
12 JAN 1984	16:32:41	194	28	35	103	164	30	34	107	5.3
12 JAN 1984	17:31:1	194	22	23	53	162	32	24	81	4.1
12 JAN 1984	17:25:15	195	59	14	87	174	49	22	113	3.2
12 JAN 1984	16:31:9	196	46	16	77	195	47	18	89	5.6
12 JAN 1984	16:51:40	196	22	39	90	172	27	44	125	1.0
13 JAN 1984	4:19:38	197	44	7	32	194	55	19	110	7.5
12 JAN 1984	16:32:7	198	106	6	67	173	75	19	149	5.9
12 JAN 1984	17:26:2	198	68	10	71	179	66	19	132	3.8
12 JAN 1984	16:48:30	199	30	25	79	103	22	42	97	6.7
12 JAN 1984	18:34:45	200	48	14	71	169	46	16	77	7.7
12 JAN 1984	16:29:59	202	63	12	79	202	63	12	79	7.4
12 JAN 1984	17:25:41	204	26	26	71	114	31	23	75	3.0
12 JAN 1984	18:48:1	204	31	21	68	149	31	44	143	7.0
12 JAN 1984	16:30:57	207	31	15	49	96	44	21	97	5.4
12 JAN 1984	16:26:24	208	23	31	75	208	23	31	75	7.2
12 JAN 1984	16:29:42	208	64	10	67	182	50	19	100	8.9
12 JAN 1984	18:34:6	209	49	11	57	151	47	25	123	8.0
12 JAN 1984	18:56:9	209	36	27	102	189	64	34	228	7.3
12 JAN 1984	17:32:30	212	50	15	79	194	65	13	89	4.0
13 JAN 1984	5:2:38	212	51	9	48	144	30	21	66	5.9
12 JAN 1984	17:31:41	213	76	13	104	159	54	24	136	4.4
12 JAN 1984	16:29:48	217	49	14	72	128	47	21	104	7.7
12 JAN 1984	17:30:21	217	45	22	104	217	45	22	104	4.2
12 JAN 1984	18:18:7	217	34	11	39	108	27	18	51	6.8
12 JAN 1984	18:46:50	217	33	28	97	196	35	29	106	6.6
12 JAN 1984	16:48:45	218	30	13	41	130	25	47	123	5.1
12 JAN 1984	16:31:35	219	64	19	128	219	64	19	128	5.5
12 JAN 1984	18:41:47	220	27	30	85	157	39	29	119	7.1
12 JAN 1984	23:29:35	221	36	12	45	100	24	32	81	7.2
12 JAN 1984	17:32:0	222	52	18	98	222	52	18	98	4.9
12 JAN 1984	16:25:25	224	40	14	59	224	40	14	59	6.9
12 JAN 1984	16:24:34	226	53	6	33	92	25	21	55	7.1
12 JAN 1984	17:28:55	227	61	11	70	227	61	11	70	6.4
12 JAN 1984	18:55:35	227	87	3	27	210	41	31	133	7.5
12 JAN 1984	17:31:9	228	37	27	105	135	38	29	116	4.5
12 JAN 1984	17:26:37	229	67	13	91	190	53	22	122	3.7
12 JAN 1984	16:25:30	230	22	24	55	230	22	24	55	7.4
12 JAN 1984	16:30:20	230	49	23	118	230	49	23	118	6.2
12 JAN 1984	17:29:47	231	55	12	69	145	51	23	123	5.2
12 JAN 1984	17:32:47	231	49	24	123	209	48	25	126	4.2
12 JAN 1984	19:1:26	231	90	19	179	205	99	18	187	6.7
12 JAN 1984	16:32:14	232	36	26	98	232	36	26	98	5.3
12 JAN 1984	16:31:57	234	56	18	106	195	68	17	121	5.3
12 JAN 1984	17:25:34	234	42	8	35	142	33	17	59	3.1
12 JAN 1984	17:26:27	234	152	2	32	111	56	15	88	4.3
12 JAN 1984	18:46:26	235	117	7	86	212	53	17	95	6.6
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12 JAN 1984	18:46:16	244	58	22	134	244	58	22	134	6.5
12 JAN 1984	18:53:7	244	51	8	43	101	29	41	125	5.8
12 JAN 1984	18:59:43	244	48	15	76	170	34	30	107	6.6
12 JAN 1984	18:58:18	247	44	15	69	180	49	21	108	6.2
12 JAN 1984	16:52:10	248	90	13	123	248	90	13	123	2.2
12 JAN 1984	17:26:53	248	94	3	30	129	42	21	93	4.4
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12 JAN 1984	18:51:50	259	59	16	99	180	54	18	102	7.0
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12 JAN 1984	17:33:13	260	54	11	62	187	41	16	69	5.4
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12 JAN 1984	17:25:56	264	48	19	96	164	56	24	141	4.0
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12 JAN 1984	17:31:48	265	61	20	128	207	59	22	136	4.7
12 JAN 1984	18:51:58	266	73	4	31	227	48	32	161	7.0
13 JAN 1984	6:40:16	266	36	20	76	266	36	20	76	6.4
12 JAN 1984	18:45:39	268	39	9	37	248	37	19	74	7.2
12 JAN 1984	19:0:18	268	55	18	104	268	55	18	104	6.3
12 JAN 1984	19:0:32	268	44	29	134	179	79	20	166	6.4
13 JAN 1984	0:22:51	269	25	37	97	269	25	37	97	8.3
12 JAN 1984	18:21:49	271	54	12	68	133	34	39	139	7.4
12 JAN 1984	19:1:14	271	23	31	75	226	27	33	93	5.9
13 JAN 1984	5:21:53	272	35	27	99	272	35	27	99	5.4
12 JAN 1984	16:26:55	273	98	4	41	187	53	15	83	6.6
12 JAN 1984	17:30:39	275	49	14	72	129	41	20	86	4.7
13 JAN 1984	4:56:10	277	31	22	72	274	55	22	127	8.5
12 JAN 1984	18:46:6	278	46	20	97	278	46	20	97	6.8
13 JAN 1984	1:3:8	278	41	14	60	152	46	27	130	8.1
13 JAN 1984	2:32:37	278	35	16	59	239	55	12	69	6.9
13 JAN 1984	1:3:44	280	66	7	48	183	49	22	113	7.9
12 JAN 1984	18:23:37	282	86	4	36	185	66	15	104	8.1
12 JAN 1984	18:43:36	282	118	3	37	124	24	26	65	7.4
13 JAN 1984	1:40:32	282	80	9	76	205	74	16	124	8.2

12 JAN 1984	16:32:32	283	40	25	105	179	51	25	134	5.0
12 JAN 1984	18:55:40	283	47	30	148	283	47	30	148	7.5
12 JAN 1984	19:1:32	283	69	9	65	154	43	23	104	6.5
13 JAN 1984	5:19:34	283	37	31	120	283	37	31	120	8.3
13 JAN 1984	6:59:26	286	33	13	45	253	30	18	57	6.7
12 JAN 1984	18:15:25	288	288	1	30	279	40	36	151	6.4
12 JAN 1984	18:46:57	288	124	13	169	223	69	24	174	6.5
12 JAN 1984	17:32:11	289	65	16	109	289	65	16	109	4.4
12 JAN 1984	18:43:19	289	43	15	68	289	43	15	68	7.5
12 JAN 1984	23:41:24	289	93	7	68	169	39	25	102	7.0
12 JAN 1984	16:44:45	291	201	2	42	174	27	20	57	7.7
12 JAN 1984	18:39:39	292	40	13	55	186	67	20	141	6.4
12 JAN 1984	18:52:4	292	116	5	61	292	116	5	61	6.7
12 JAN 1984	18:57:42	292	51	17	91	161	42	30	132	6.7
13 JAN 1984	0:1:45	292	56	27	159	292	56	27	159	8.3
13 JAN 1984	0:42:44	292	75	9	71	195	46	19	92	7.7
13 JAN 1984	1:20:13	292	38	24	96	292	38	24	96	8.5
12 JAN 1984	16:26:3	293	46	14	68	155	53	23	128	6.7
13 JAN 1984	1:56:3	293	65	11	75	203	67	12	84	4.3
12 JAN 1984	18:47:55	294	64	10	67	133	51	21	112	7.1
12 JAN 1984	23:40:7	294	130	5	68	138	41	19	82	6.7
13 JAN 1984	0:58:54	295	31	31	101	169	38	34	136	8.8
13 JAN 1984	2:2:48	295	64	7	47	171	41	21	90	8.3
13 JAN 1984	2:35:45	295	72	11	83	262	91	10	95	7.1
12 JAN 1984	23:42:4	296	56	12	71	112	30	30	94	9.8
12 JAN 1984	19:44:12	297	297	1	31	153	40	18	76	7.6
12 JAN 1984	21:26:43	298	84	6	53	204	55	18	104	6.0
13 JAN 1984	2:15:44	298	48	7	35	267	53	22	122	9.3
12 JAN 1984	18:49:30	299	66	9	62	170	49	22	113	6.9
12 JAN 1984	18:53:1	300	20	40	84	300	20	40	84	6.1
12 JAN 1984	18:54:12	301	77	12	97	206	41	27	116	7.1
12 JAN 1984	17:35:3	302	49	11	57	130	36	16	60	5.8
13 JAN 1984	4:58:50	302	77	7	57	302	77	7	57	5.5
12 JAN 1984	18:27:53	303	64	9	60	303	64	9	60	9.6
12 JAN 1984	18:35:1	303	56	15	88	209	44	20	92	7.5
13 JAN 1984	5:8:7	303	29	28	85	303	29	28	85	7.8
12 JAN 1984	18:21:24	304	31	29	94	304	31	29	94	7.3
12 JAN 1984	19:2:40	305	50	36	189	305	50	36	189	7.5
13 JAN 1984	2:18:11	305	31	22	72	226	43	30	135	8.3
12 JAN 1984	16:44:55	306	306	1	32	248	55	6	35	6.4
12 JAN 1984	18:56:16	306	44	21	97	203	75	22	173	6.9
12 JAN 1984	21:9:17	306	60	9	57	190	36	18	68	7.1
13 JAN 1984	2:27:18	308	93	11	107	308	93	11	107	7.8
12 JAN 1984	18:19:14	309	46	12	58	183	48	13	65	6.2
12 JAN 1984	18:32:28	309	22	28	65	87	26	29	79	7.8
12 JAN 1984	18:48:33	309	39	24	98	174	28	34	100	7.2
12 JAN 1984	19:22:45	310	74	9	70	274	33	28	97	6.0
12 JAN 1984	19:27:48	311	85	12	107	223	60	18	113	8.3
12 JAN 1984	19:18:33	312	41	13	56	123	47	18	89	7.6
13 JAN 1984	2:33:7	313	39	11	45	240	69	22	159	7.2
12 JAN 1984	17:25:27	314	70	12	88	264	27	35	99	2.4
13 JAN 1984	1:46:2	314	71	11	82	314	71	11	82	7.0
13 JAN 1984	2:31:35	316	50	18	94	292	68	14	100	7.6
13 JAN 1984	4:58:2	317	42	21	93	202	39	24	98	6.2
12 JAN 1984	21:28:55	319	74	10	78	228	65	13	89	2.6
13 JAN 1984	1:38:5	320	33	20	69	177	69	20	145	7.6
12 JAN 1984	18:33:16	321	41	9	39	160	37	42	163	8.6
13 JAN 1984	1:27:0	321	69	12	87	193	67	14	98	8.5
12 JAN 1984	18:58:54	322	140	4	59	221	68	17	121	6.7
12 JAN 1984	16:25:36	323	51	8	43	314	62	7	46	6.4
13 JAN 1984	5:40:31	323	44	25	115	162	54	31	176	8.6

13 JAN 1984	6:57:8	323	70	6	44	323	70	6	44	7.5
12 JAN 1984	18:35:39	325	53	14	78	325	53	14	78	7.6
12 JAN 1984	18:33:33	326	75	9	71	234	52	31	169	8.3
12 JAN 1984	18:43:55	326	39	32	131	326	39	32	131	7.2
13 JAN 1984	1:47:23	326	40	17	71	314	108	10	113	6.7
12 JAN 1984	16:48:2	328	47	25	123	97	27	44	125	10.4
13 JAN 1984	1:38:30	329	329	1	35	172	39	18	74	7.0
13 JAN 1984	3:54:29	329	59	14	87	329	59	14	87	6.3
13 JAN 1984	6:56:25	329	44	14	65	292	29	27	82	9.1
12 JAN 1984	19:1:4	330	87	8	73	140	38	20	80	6.0
13 JAN 1984	1:38:20	330	73	8	61	221	112	11	129	6.9
12 JAN 1984	18:46:40	332	60	6	38	192	29	19	58	6.6
12 JAN 1984	18:44:10	334	48	31	156	268	83	22	192	7.4
13 JAN 1984	2:29:47	336	111	7	82	336	111	7	82	7.5
13 JAN 1984	2:37:24	336	53	11	61	336	53	11	61	1.2
12 JAN 1984	18:20:41	339	78	5	41	177	28	21	62	7.8
13 JAN 1984	1:50:43	339	70	9	66	315	49	32	165	7.7
13 JAN 1984	4:47:58	339	339	1	36	179	35	18	66	7.2
13 JAN 1984	5:42:16	340	68	16	114	243	61	18	115	2.4
12 JAN 1984	18:56:43	341	58	14	85	247	42	23	101	6.4
12 JAN 1984	18:59:4	341	70	14	103	182	75	18	142	6.4
12 JAN 1984	20:48:26	341	51	20	107	269	41	25	108	6.7
13 JAN 1984	2:2:42	341	27	25	71	114	50	17	89	8.3
13 JAN 1984	4:45:55	341	73	9	69	140	27	40	113	9.2
13 JAN 1984	1:48:33	342	51	14	75	308	44	19	88	6.4
13 JAN 1984	2:32:48	342	89	5	47	141	35	25	92	7.2
13 JAN 1984	2:31:21	343	81	6	51	207	58	19	116	8.0
13 JAN 1984	3:45:29	343	51	12	64	343	51	12	64	6.6
13 JAN 1984	3:49:24	343	45	24	113	343	45	24	113	6.7
12 JAN 1984	19:36:35	344	22	33	76	215	54	18	102	6.3
13 JAN 1984	5:11:11	345	43	17	77	161	33	32	111	8.1
12 JAN 1984	18:49:42	347	48	46	232	268	52	44	240	7.1
12 JAN 1984	18:47:12	348	29	19	58	348	29	19	58	6.4
13 JAN 1984	1:4:54	348	38	16	64	245	43	21	95	8.6
13 JAN 1984	0:43:30	349	59	12	74	141	27	30	85	7.9
13 JAN 1984	2:33:22	349	65	13	89	166	34	35	125	6.6
13 JAN 1984	5:10:43	349	78	7	57	232	75	11	87	7.3
13 JAN 1984	1:25:38	350	62	10	65	198	57	12	72	8.4
13 JAN 1984	2:25:14	351	100	9	94	276	27	34	96	7.8
13 JAN 1984	5:17:29	352	58	16	97	352	58	16	97	8.6
13 JAN 1984	2:22:21	353	49	15	77	241	43	28	126	7.0
12 JAN 1984	18:48:15	355	34	15	54	172	40	21	88	6.9
13 JAN 1984	2:25:56	355	170	3	54	183	56	11	65	6.4
13 JAN 1984	1:25:21	356	54	8	45	291	57	14	84	8.6
13 JAN 1984	5:40:12	356	32	21	71	338	66	30	208	9.5
13 JAN 1984	1:37:45	357	42	23	101	264	59	23	142	8.6
13 JAN 1984	2:20:48	358	42	19	84	358	42	19	84	6.9
13 JAN 1984	5:23:46	358	358	1	38	198	49	22	113	5.3
13 JAN 1984	0:41:46	359	126	3	40	314	79	19	157	7.5
13 JAN 1984	2:26:59	359	73	14	107	359	73	14	107	7.2
12 JAN 1984	18:55:16	360	37	28	109	180	44	30	138	7.9
13 JAN 1984	1:50:35	360	50	30	157	178	51	34	182	8.6
13 JAN 1984	1:16:43	362	39	20	82	304	48	17	86	7.3
13 JAN 1984	1:54:2	362	110	10	115	346	75	15	118	5.2
12 JAN 1984	23:21:34	363	66	17	118	303	80	16	134	4.1
13 JAN 1984	5:40:48	363	48	31	156	189	42	41	181	8.4
12 JAN 1984	18:51:42	364	48	18	91	313	54	16	91	6.8
13 JAN 1984	0:2:34	365	187	2	39	253	92	10	97	7.2
13 JAN 1984	2:34:53	366	108	6	68	254	63	13	86	6.5
12 JAN 1984	18:50:18	367	161	3	51	203	64	17	114	7.0
12 JAN 1984	17:28:23	368	35	23	84	335	35	24	88	7.0

12 JAN 1984	18:44:36	371	49	39	200	371	49	39	200	7.6
12 JAN 1984	23:26:30	371	52	17	93	327	76	16	128	7.9
13 JAN 1984	2:30:49	376	149	3	47	148	51	23	123	7.9
12 JAN 1984	23:19:41	378	105	9	99	256	104	13	142	4.2
13 JAN 1984	3:51:55	378	93	5	49	204	29	32	97	6.4
13 JAN 1984	4:52:56	378	50	15	79	172	32	36	121	6.8
12 JAN 1984	21:27:17	379	65	16	109	210	42	27	119	4.7
13 JAN 1984	1:46:21	379	38	22	88	216	45	19	90	7.4
12 JAN 1984	20:42:55	380	47	14	69	201	22	39	90	9.2
13 JAN 1984	3:55:33	380	36	16	60	116	30	25	79	7.2
13 JAN 1984	2:21:50	381	52	12	65	262	43	32	144	6.7
13 JAN 1984	1:41:52	382	133	5	70	326	86	13	117	8.5
12 JAN 1984	18:16:54	384	33	29	100	384	33	29	100	6.7
13 JAN 1984	6:39:2	385	45	22	104	385	45	22	104	4.2
12 JAN 1984	19:37:47	387	56	20	118	387	56	20	118	7.0
13 JAN 1984	1:58:47	387	143	5	75	274	104	13	142	7.5
13 JAN 1984	2:25:24	389	73	8	61	151	57	13	78	7.6
12 JAN 1984	22:40:8	390	53	18	100	266	55	21	121	5.3
12 JAN 1984	18:44:19	391	47	21	104	207	38	38	151	7.7
12 JAN 1984	19:1:26	391	47	20	99	264	59	33	204	6.4
13 JAN 1984	4:40:18	394	80	12	101	314	71	20	149	5.8
12 JAN 1984	21:10:34	396	89	17	159	341	82	19	163	7.0
13 JAN 1984	2:24:19	406	77	15	121	327	118	14	173	7.2
13 JAN 1984	2:26:15	406	56	9	53	184	40	17	71	7.1
12 JAN 1984	18:56:58	408	61	19	122	119	43	28	126	6.6
13 JAN 1984	0:39:0	409	99	6	62	409	99	6	62	7.9
13 JAN 1984	2:34:32	413	87	10	91	240	63	29	192	7.1
13 JAN 1984	4:40:5	413	99	6	62	239	51	30	161	5.9
12 JAN 1984	18:52:33	414	165	7	121	310	76	19	151	6.2
12 JAN 1984	23:29:57	414	36	32	121	414	36	32	121	7.1
13 JAN 1984	1:44:53	415	243	2	51	415	243	2	51	7.2
13 JAN 1984	5:21:6	416	51	22	118	416	51	22	118	7.7
13 JAN 1984	2:34:4	421	62	39	254	421	62	39	254	6.6
13 JAN 1984	5:24:12	423	423	1	44	275	73	21	161	5.4
13 JAN 1984	0:17:7	428	104	5	55	145	25	24	63	8.3
13 JAN 1984	1:31:55	431	93	13	127	133	54	24	136	9.1
13 JAN 1984	1:42:45	432	432	1	45	267	47	17	84	7.7
12 JAN 1984	18:59:25	438	66	12	83	438	66	12	83	6.0
13 JAN 1984	6:36:8	439	82	9	77	247	59	21	130	4.4
13 JAN 1984	2:35:56	440	56	30	176	334	75	34	268	6.7
12 JAN 1984	20:46:56	441	441	1	46	260	62	15	98	7.7
13 JAN 1984	6:36:44	444	444	1	47	424	78	15	123	4.1
13 JAN 1984	2:31:47	460	52	23	125	460	52	23	125	7.7
13 JAN 1984	0:41:53	461	33	25	87	126	28	34	100	7.9
12 JAN 1984	19:18:47	464	53	15	83	279	42	20	88	6.0
13 JAN 1984	1:43:14	467	63	13	86	275	55	20	115	8.0
13 JAN 1984	5:12:43	473	188	5	99	356	119	8	100	7.9
12 JAN 1984	19:39:3	484	57	43	257	484	57	43	257	9.8
13 JAN 1984	0:57:54	484	40	20	84	313	66	18	125	6.3
13 JAN 1984	4:54:50	489	45	34	161	489	45	34	161	9.0
13 JAN 1984	0:54:15	494	68	10	71	406	57	17	102	5.2
13 JAN 1984	0:48:32	496	496	1	52	433	53	22	122	5.5
13 JAN 1984	0:40:11	497	67	9	63	216	38	27	108	7.5
13 JAN 1984	1:41:3	500	170	4	71	265	67	19	134	7.6
13 JAN 1984	0:58:5	506	58	22	134	506	58	22	134	6.0
13 JAN 1984	4:36:32	514	52	27	147	514	52	27	147	7.7
13 JAN 1984	0:54:42	528	58	20	122	390	62	19	124	3.8
13 JAN 1984	0:58:34	537	48	27	136	492	50	28	147	5.7
13 JAN 1984	0:40:48	550	32	22	74	219	44	37	171	7.5
13 JAN 1984	0:56:29	550	55	19	110	505	49	24	123	6.0
13 JAN 1984	2:14:8	553	553	1	58	87	26	29	79	8.2

13 JAN 1984	0:54:37	564	71	20	149	491	60	24	151	5.1
13 JAN 1984	2:17:35	564	96	8	81	564	96	8	81	9.0
13 JAN 1984	5:9:44	580	580	1	61	278	70	12	88	8.8
13 JAN 1984	0:55:48	582	59	17	105	170	62	18	117	3.5
13 JAN 1984	2:21:0	588	37	29	113	528	31	37	120	6.6
13 JAN 1984	5:21:27	589	91	11	105	447	60	17	107	6.1
13 JAN 1984	5:20:51	594	57	23	138	594	57	23	138	9.3

APPENDIX B

SUMMARY OF MEASURED DATA RANKED BY TOTAL PANEL FORCE

KEY:

PM1 - Maximum single sub-panel pressure (psi)
PA1 - Average pressure over the contact area at the time of peak pressure (psi)
A1 - Contact area at the time of peak pressure (sub-panels)
F1 - Total panel force at the time of peak pressure (LT)
PM2 - Maximum single sub-panel force (psi)
PA2 - Average pressure over the contact area at the time of peak force (psi)
A2 - Contact area at the time of peak force (sub-panels)
F2 - Peak total panel force (LT)
VEL - Ship velocity at impact

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 JAN 1984	16:44:55	306	306	1	32	248	55	6	35	6.4
12 JAN 1984	17:27:53	255	105	3	33	141	45	9	42	5.2
13 JAN 1984	6:57:8	323	70	6	44	323	70	6	44	7.5
12 JAN 1984	16:25:36	323	51	8	43	314	62	7	46	6.4
12 JAN 1984	16:51:48	155	56	8	47	143	81	6	51	1.3
12 JAN 1984	18:18:7	217	34	11	39	108	27	18	51	6.8
13 JAN 1984	1:44:53	415	243	2	51	415	243	2	51	7.2
12 JAN 1984	16:24:34	226	53	6	33	92	25	21	55	7.1
12 JAN 1984	16:25:30	230	22	24	55	230	22	24	55	7.4
12 JAN 1984	16:44:45	291	201	2	42	174	27	20	57	7.7
13 JAN 1984	4:58:50	302	77	7	57	302	77	7	57	5.5
13 JAN 1984	6:59:26	286	33	13	45	253	30	18	57	6.7
12 JAN 1984	18:46:40	332	60	6	38	192	29	19	58	6.6
12 JAN 1984	18:47:12	348	29	19	58	348	29	19	58	6.4
12 JAN 1984	16:25:25	224	40	14	59	224	40	14	59	6.9
12 JAN 1984	17:25:34	234	42	8	35	142	33	17	59	3.1
12 JAN 1984	17:28:47	193	28	15	44	132	63	9	59	7.1
12 JAN 1984	18:28:48	238	38	12	48	192	21	27	59	7.8
12 JAN 1984	18:47:37	257	80	7	59	257	80	7	59	7.6
12 JAN 1984	16:52:25	154	42	13	57	131	44	13	60	1.8
12 JAN 1984	17:35:3	302	49	11	57	130	36	16	60	5.8
12 JAN 1984	18:27:53	303	64	9	60	303	64	9	60	9.6
12 JAN 1984	18:53:46	237	62	9	59	217	57	10	60	6.3
12 JAN 1984	18:52:4	292	116	5	61	292	116	5	61	6.7
13 JAN 1984	2:37:24	336	53	11	61	336	53	11	61	1.2
12 JAN 1984	18:20:41	339	78	5	41	177	28	21	62	7.8
13 JAN 1984	0:39:0	409	99	6	62	409	99	6	62	7.9
12 JAN 1984	17:28:38	177	42	14	62	77	26	23	63	6.8
13 JAN 1984	0:17:7	428	104	5	55	145	25	24	63	8.3
13 JAN 1984	3:45:29	343	51	12	64	343	51	12	64	6.6
12 JAN 1984	17:29:22	260	80	7	59	259	89	7	65	5.3
12 JAN 1984	18:19:14	309	46	12	58	183	48	13	65	6.2
12 JAN 1984	18:43:36	282	118	3	37	124	24	26	65	7.4
12 JAN 1984	18:50:56	257	67	6	42	216	88	7	65	7.1
13 JAN 1984	2:25:56	355	170	3	54	183	56	11	65	6.4
12 JAN 1984	17:30:54	139	70	7	51	119	45	14	66	4.2
12 JAN 1984	18:21:4	248	74	5	39	233	33	19	66	7.6
13 JAN 1984	4:47:58	339	339	1	36	179	35	18	66	7.2
13 JAN 1984	5:2:38	212	51	9	48	144	30	21	66	5.9
12 JAN 1984	18:43:19	289	43	15	68	289	43	15	68	7.5
12 JAN 1984	21:9:17	306	60	9	57	190	36	18	68	7.1
12 JAN 1984	17:33:13	260	54	11	62	187	41	16	69	5.4
12 JAN 1984	18:54:34	240	106	6	67	130	33	20	69	7.3
13 JAN 1984	2:32:37	278	35	16	59	239	55	12	69	6.9
12 JAN 1984	17:28:55	227	61	11	70	227	61	11	70	6.4
13 JAN 1984	2:26:15	406	56	9	53	184	40	17	71	7.1
13 JAN 1984	1:25:38	350	62	10	65	198	57	12	72	8.4
12 JAN 1984	18:45:39	268	39	9	37	248	37	19	74	7.2
13 JAN 1984	1:38:30	329	329	1	35	172	39	18	74	7.0
12 JAN 1984	16:26:24	208	23	31	75	208	23	31	75	7.2
12 JAN 1984	17:25:41	204	26	26	71	114	31	23	75	3.0
12 JAN 1984	17:26:9	152	41	7	30	123	42	17	75	3.5
12 JAN 1984	16:45:1	178	22	33	76	178	22	33	76	6.5
12 JAN 1984	19:44:12	297	297	1	31	153	40	18	76	7.6
13 JAN 1984	6:40:16	266	36	20	76	266	36	20	76	6.4
12 JAN 1984	18:34:45	200	48	14	71	169	46	16	77	7.7
12 JAN 1984	18:35:39	325	53	14	78	325	53	14	78	7.6
13 JAN 1984	2:25:24	389	73	8	61	151	57	13	78	7.6
12 JAN 1984	16:29:59	202	63	12	79	202	63	12	79	7.4

12 JAN 1984	18:32:28	309	22	28	65	87	26	29	79	7.8
13 JAN 1984	2:14:8	553	553	1	58	87	26	29	79	8.2
13 JAN 1984	3:55:33	380	36	16	60	116	30	25	79	7.2
12 JAN 1984	19:1:4	330	87	8	73	140	38	20	80	6.0
12 JAN 1984	16:25:6	263	48	8	40	85	22	35	81	8.0
12 JAN 1984	17:31:1	194	22	23	53	162	32	24	81	4.1
12 JAN 1984	23:29:35	221	36	12	45	100	24	32	81	7.2
13 JAN 1984	2:17:35	564	96	8	81	564	96	8	81	9.0
12 JAN 1984	23:40:7	294	130	5	68	138	41	19	82	6.7
13 JAN 1984	1:46:2	314	71	11	82	314	71	11	82	7.0
13 JAN 1984	2:29:47	336	111	7	82	336	111	7	82	7.5
13 JAN 1984	6:56:25	329	44	14	65	292	29	27	82	9.1
12 JAN 1984	16:26:55	273	98	4	41	187	53	15	83	6.6
12 JAN 1984	18:59:25	438	66	12	83	438	66	12	83	6.0
12 JAN 1984	18:53:1	300	20	40	84	300	20	40	84	6.1
13 JAN 1984	1:25:21	356	54	8	45	291	57	14	84	8.6
13 JAN 1984	1:42:45	432	432	1	45	267	47	17	84	7.7
13 JAN 1984	1:56:3	293	65	11	75	203	67	12	84	4.3
13 JAN 1984	2:20:48	358	42	19	84	358	42	19	84	6.9
13 JAN 1984	0:43:30	349	59	12	74	141	27	30	85	7.9
13 JAN 1984	5:8:7	303	29	28	85	303	29	28	85	7.8
12 JAN 1984	17:30:39	275	49	14	72	129	41	20	86	4.7
13 JAN 1984	1:16:43	362	39	20	82	304	48	17	86	7.3
13 JAN 1984	2:34:53	366	108	6	68	254	63	13	86	6.5
13 JAN 1984	3:54:29	329	59	14	87	329	59	14	87	6.3
13 JAN 1984	5:10:43	349	78	7	57	232	75	11	87	7.3
12 JAN 1984	17:26:27	234	152	2	32	111	56	15	88	4.3
12 JAN 1984	17:28:23	368	35	23	84	335	35	24	88	7.0
12 JAN 1984	18:48:15	355	34	15	54	172	40	21	88	6.9
12 JAN 1984	19:18:47	464	53	15	83	279	42	20	88	6.0
13 JAN 1984	1:48:33	342	51	14	75	308	44	19	88	6.4
13 JAN 1984	5:9:44	580	580	1	61	278	70	12	88	8.8
12 JAN 1984	16:31:9	196	46	16	77	195	47	18	89	5.6
12 JAN 1984	17:32:30	212	50	15	79	194	65	13	89	4.0
12 JAN 1984	19:18:33	312	41	13	56	123	47	18	89	7.6
12 JAN 1984	21:28:55	319	74	10	78	228	65	13	89	2.6
13 JAN 1984	2:2:42	341	27	25	71	114	50	17	89	8.3
12 JAN 1984	17:32:19	249	45	19	90	249	45	19	90	4.2
12 JAN 1984	20:42:55	380	47	14	69	201	22	39	90	9.2
13 JAN 1984	1:46:21	379	38	22	88	216	45	19	90	7.4
13 JAN 1984	2:2:48	295	64	7	47	171	41	21	90	8.3
12 JAN 1984	18:51:42	364	48	18	91	313	54	16	91	6.8
12 JAN 1984	18:20:21	262	27	25	71	160	22	40	92	5.8
12 JAN 1984	18:35:1	303	56	15	88	209	44	20	92	7.5
13 JAN 1984	0:42:44	292	75	9	71	195	46	19	92	7.7
13 JAN 1984	2:32:48	342	89	5	47	141	35	25	92	7.2
12 JAN 1984	17:26:53	248	94	3	30	129	42	21	93	4.4
12 JAN 1984	19:1:14	271	23	31	75	226	27	33	93	5.9
12 JAN 1984	18:21:24	304	31	29	94	304	31	29	94	7.3
12 JAN 1984	18:49:18	235	23	28	68	164	32	28	94	6.8
12 JAN 1984	23:42:4	296	56	12	71	112	30	30	94	9.8
12 JAN 1984	18:46:26	235	117	7	86	212	53	17	95	6.6
13 JAN 1984	1:4:54	348	38	16	64	245	43	21	95	8.6
13 JAN 1984	2:35:45	295	72	11	83	262	91	10	95	7.1
12 JAN 1984	17:31:30	263	138	4	58	130	48	19	96	4.6
13 JAN 1984	1:20:13	292	38	24	96	292	38	24	96	8.5
13 JAN 1984	2:25:14	351	100	9	94	276	27	34	96	7.8
12 JAN 1984	16:30:57	207	31	15	49	96	44	21	97	5.4
12 JAN 1984	16:48:30	199	30	25	79	103	22	42	97	6.7
12 JAN 1984	18:46:6	278	46	20	97	278	46	20	97	6.8
12 JAN 1984	19:22:45	310	74	9	70	274	33	28	97	6.0

13 JAN 1984	0:2:34	365	187	2	39	253	92	10	97	7.2
13 JAN 1984	0:22:51	269	25	37	97	269	25	37	97	8.3
13 JAN 1984	3:51:55	378	93	5	49	204	29	32	97	6.4
13 JAN 1984	5:17:29	352	58	16	97	352	58	16	97	8.6
12 JAN 1984	16:32:14	232	36	26	98	232	36	26	98	5.3
12 JAN 1984	17:32:0	222	52	18	98	222	52	18	98	4.9
12 JAN 1984	20:46:56	441	441	1	46	260	62	15	98	7.7
13 JAN 1984	1:27:0	321	69	12	87	193	67	14	98	8.5
13 JAN 1984	4:58:2	317	42	21	93	202	39	24	98	6.2
12 JAN 1984	17:25:27	314	70	12	88	264	27	35	99	2.4
13 JAN 1984	5:21:53	272	35	27	99	272	35	27	99	5.4
12 JAN 1984	16:29:42	208	64	10	67	182	50	19	100	8.9
12 JAN 1984	18:16:54	384	33	29	100	384	33	29	100	6.7
12 JAN 1984	18:48:33	309	39	24	98	174	28	34	100	7.2
13 JAN 1984	0:41:53	461	33	25	87	126	28	34	100	7.9
13 JAN 1984	2:31:35	316	50	18	94	292	68	14	100	7.6
13 JAN 1984	5:12:43	473	188	5	99	356	119	8	100	7.9
12 JAN 1984	18:49:12	239	46	18	87	232	74	13	101	7.0
12 JAN 1984	18:56:43	341	58	14	85	247	42	23	101	6.4
12 JAN 1984	18:51:50	259	59	16	99	180	54	18	102	7.0
12 JAN 1984	19:36:35	344	22	33	76	215	54	18	102	6.3
12 JAN 1984	23:41:24	289	93	7	68	169	39	25	102	7.0
13 JAN 1984	0:54:15	494	68	10	71	406	57	17	102	5.2
12 JAN 1984	16:29:48	217	49	14	72	128	47	21	104	7.7
12 JAN 1984	17:24:44	193	27	26	74	165	47	21	104	1.7
12 JAN 1984	17:30:11	239	46	17	82	130	52	19	104	4.4
12 JAN 1984	17:30:21	217	45	22	104	217	45	22	104	4.2
12 JAN 1984	18:23:37	282	86	4	36	185	66	15	104	8.1
12 JAN 1984	19:0:18	268	55	18	104	268	55	18	104	6.3
12 JAN 1984	19:1:32	283	69	9	65	154	43	23	104	6.5
12 JAN 1984	21:26:43	298	84	6	53	204	55	18	104	6.0
12 JAN 1984	23:26:6	260	75	13	102	223	90	11	104	4.8
13 JAN 1984	6:39:2	385	45	22	104	385	45	22	104	4.2
12 JAN 1984	16:32:26	252	38	23	92	181	63	16	106	4.9
12 JAN 1984	17:27:12	175	63	16	106	175	63	16	106	4.3
12 JAN 1984	18:46:50	217	33	28	97	196	35	29	106	6.6
12 JAN 1984	16:32:41	194	28	35	103	164	30	34	107	5.3
12 JAN 1984	18:59:43	244	48	15	76	170	34	30	107	6.6
13 JAN 1984	2:26:59	359	73	14	107	359	73	14	107	7.2
13 JAN 1984	2:27:18	308	93	11	107	308	93	11	107	7.8
13 JAN 1984	5:21:27	589	91	11	105	447	60	17	107	6.1
12 JAN 1984	18:58:18	247	44	15	69	180	49	21	108	6.2
12 JAN 1984	20:48:26	341	51	20	107	269	41	25	108	6.7
13 JAN 1984	0:40:11	497	67	9	63	216	38	27	108	7.5
12 JAN 1984	16:27:28	254	47	20	99	220	52	20	109	7.2
12 JAN 1984	17:32:11	289	65	16	109	289	65	16	109	4.4
12 JAN 1984	18:41:14	242	69	15	109	242	69	15	109	6.6
13 JAN 1984	4:19:38	197	44	7	32	194	55	19	110	7.5
12 JAN 1984	16:30:52	244	49	17	87	186	62	17	111	5.2
13 JAN 1984	5:11:11	345	43	17	77	161	33	32	111	8.1
12 JAN 1984	18:47:55	294	64	10	67	133	51	21	112	7.1
12 JAN 1984	17:25:15	195	59	14	87	174	49	22	113	3.2
12 JAN 1984	18:45:17	252	93	6	59	161	49	22	113	7.2
12 JAN 1984	18:49:30	299	66	9	62	170	49	22	113	6.9
12 JAN 1984	19:27:48	311	85	12	107	223	60	18	113	8.3
13 JAN 1984	1:3:44	280	66	7	48	183	49	22	113	7.9
13 JAN 1984	1:47:23	326	40	17	71	314	108	10	113	6.7
13 JAN 1984	3:49:24	343	45	24	113	343	45	24	113	6.7
13 JAN 1984	4:45:55	341	73	9	69	140	27	40	113	9.2
13 JAN 1984	5:23:46	358	358	1	38	198	49	22	113	5.3
12 JAN 1984	18:50:18	367	161	3	51	203	64	17	114	7.0

13 JAN 1984	1:43:14	467	63	13	86	275	55	20	115	8.0
13 JAN 1984	5:42:16	340	68	16	114	243	61	18	115	2.4
12 JAN 1984	17:31:9	228	37	27	105	135	38	29	116	4.5
12 JAN 1984	18:54:12	301	77	12	97	206	41	27	116	7.1
13 JAN 1984	2:31:21	343	81	6	51	207	58	19	116	8.0
13 JAN 1984	0:55:48	582	59	17	105	170	62	18	117	3.5
13 JAN 1984	1:41:52	382	133	5	70	326	86	13	117	8.5
12 JAN 1984	16:30:20	230	49	23	118	230	49	23	118	6.2
12 JAN 1984	19:37:47	387	56	20	118	387	56	20	118	7.0
13 JAN 1984	1:54:2	362	110	10	115	346	75	15	118	5.2
13 JAN 1984	5:21:6	416	51	22	118	416	51	22	118	7.7
12 JAN 1984	18:41:47	220	27	30	85	157	39	29	119	7.1
12 JAN 1984	21:27:17	379	65	16	109	210	42	27	119	4.7
12 JAN 1984	18:58:2	253	47	21	104	164	52	22	120	6.5
13 JAN 1984	2:21:0	588	37	29	113	528	31	37	120	6.6
13 JAN 1984	5:19:34	283	37	31	120	283	37	31	120	8.3
12 JAN 1984	16:31:57	234	56	18	106	195	68	17	121	5.3
12 JAN 1984	18:58:54	322	140	4	59	221	68	17	121	6.7
12 JAN 1984	22:40:8	390	53	18	100	266	55	21	121	5.3
12 JAN 1984	23:29:57	414	36	32	121	414	36	32	121	7.1
13 JAN 1984	4:52:56	378	50	15	79	172	32	36	121	6.8
12 JAN 1984	17:26:37	229	67	13	91	190	53	22	122	3.7
12 JAN 1984	18:39:10	238	74	9	70	133	40	29	122	6.6
13 JAN 1984	0:48:32	496	496	1	52	433	53	22	122	5.5
13 JAN 1984	2:15:44	298	48	7	35	267	53	22	122	9.3
12 JAN 1984	16:48:45	218	30	13	41	130	25	47	123	5.1
12 JAN 1984	16:52:10	248	90	13	123	248	90	13	123	2.2
12 JAN 1984	17:29:47	231	55	12	69	145	51	23	123	5.2
12 JAN 1984	18:34:6	209	49	11	57	151	47	25	123	8.0
12 JAN 1984	18:40:42	255	62	17	111	228	39	30	123	6.5
13 JAN 1984	0:56:29	550	55	19	110	505	49	24	123	6.0
13 JAN 1984	2:30:49	376	149	3	47	148	51	23	123	7.9
13 JAN 1984	6:36:44	444	444	1	47	424	78	15	123	4.1
13 JAN 1984	0:54:42	528	58	20	122	390	62	19	124	3.8
13 JAN 1984	1:40:32	282	80	9	76	205	74	16	124	8.2
13 JAN 1984	3:37:29	260	127	3	40	185	62	19	124	6.7
12 JAN 1984	16:48:2	328	47	25	123	97	27	44	125	10.4
12 JAN 1984	16:51:40	196	22	39	90	172	27	44	125	1.0
12 JAN 1984	17:31:53	188	61	13	83	128	52	23	125	4.8
12 JAN 1984	18:53:7	244	51	8	43	101	29	41	125	5.8
13 JAN 1984	0:57:54	484	40	20	84	313	66	18	125	6.3
13 JAN 1984	2:31:47	460	52	23	125	460	52	23	125	7.7
13 JAN 1984	2:33:22	349	65	13	89	166	34	35	125	6.6
12 JAN 1984	17:32:47	231	49	24	123	209	48	25	126	4.2
12 JAN 1984	18:56:58	408	61	19	122	119	43	28	126	6.6
13 JAN 1984	2:22:21	353	49	15	77	241	43	28	126	7.0
12 JAN 1984	16:31:40	238	46	20	97	167	55	22	127	5.6
13 JAN 1984	4:56:10	277	31	22	72	274	55	22	127	8.5
12 JAN 1984	16:26:3	293	46	14	68	155	53	23	128	6.7
12 JAN 1984	16:31:35	219	64	19	128	219	64	19	128	5.5
12 JAN 1984	23:26:30	371	52	17	93	327	76	16	128	7.9
12 JAN 1984	16:48:19	244	29	35	106	134	25	49	129	8.1
13 JAN 1984	1:38:20	330	73	8	61	221	112	11	129	6.9
13 JAN 1984	1:3:8	278	41	14	60	152	46	27	130	8.1
13 JAN 1984	6:36:8	439	82	9	77	247	59	21	130	4.4
12 JAN 1984	18:43:55	326	39	32	131	326	39	32	131	7.2
12 JAN 1984	17:26:2	198	68	10	71	179	66	19	132	3.8
12 JAN 1984	18:57:42	292	51	17	91	161	42	30	132	6.7
12 JAN 1984	18:55:35	227	87	3	27	210	41	31	133	7.5
12 JAN 1984	16:27:44	184	45	15	71	171	49	26	134	7.2
12 JAN 1984	16:32:32	283	40	25	105	179	51	25	134	5.0

12 JAN 1984	18:46:16	244	58	22	134	244	58	22	134	6.5
12 JAN 1984	23:21:34	363	66	17	118	303	80	16	134	4.1
13 JAN 1984	0:58:5	506	58	22	134	506	58	22	134	6.0
13 JAN 1984	1:41:3	500	170	4	71	265	67	19	134	7.6
13 JAN 1984	2:18:11	305	31	22	72	226	43	30	135	8.3
12 JAN 1984	17:31:41	213	76	13	104	159	54	24	136	4.4
12 JAN 1984	17:31:48	265	61	20	128	207	59	22	136	4.7
13 JAN 1984	0:58:54	295	31	31	101	169	38	34	136	8.8
13 JAN 1984	1:31:55	431	93	13	127	133	54	24	136	9.1
12 JAN 1984	18:55:16	360	37	28	109	180	44	30	138	7.9
13 JAN 1984	5:20:51	594	57	23	138	594	57	23	138	9.3
12 JAN 1984	18:21:49	271	54	12	68	133	34	39	139	7.4
12 JAN 1984	17:25:56	264	48	19	96	164	56	24	141	4.0
12 JAN 1984	18:39:39	292	40	13	55	186	67	20	141	6.4
12 JAN 1984	18:59:4	341	70	14	103	182	75	18	142	6.4
12 JAN 1984	18:59:49	258	59	23	142	258	59	23	142	6.3
12 JAN 1984	23:19:41	378	105	9	99	256	104	13	142	4.2
13 JAN 1984	1:37:45	357	42	23	101	264	59	23	142	8.6
13 JAN 1984	1:58:47	387	143	5	75	274	104	13	142	7.5
12 JAN 1984	18:48:1	204	31	21	68	149	31	44	143	7.0
12 JAN 1984	16:33:9	173	32	42	141	164	32	43	144	5.0
12 JAN 1984	19:36:12	241	51	27	144	241	51	27	144	8.0
13 JAN 1984	2:21:50	381	52	12	65	262	43	32	144	6.7
13 JAN 1984	1:38:5	320	33	20	69	177	69	20	145	7.6
13 JAN 1984	0:58:34	537	48	27	136	492	50	28	147	5.7
13 JAN 1984	4:36:32	514	52	27	147	514	52	27	147	7.7
12 JAN 1984	18:55:40	283	47	30	148	283	47	30	148	7.5
12 JAN 1984	16:32:7	198	106	6	67	173	75	19	149	5.9
13 JAN 1984	4:40:18	394	80	12	101	314	71	20	149	5.8
12 JAN 1984	18:15:25	288	288	1	30	279	40	36	151	6.4
12 JAN 1984	18:44:19	391	47	21	104	207	38	38	151	7.7
12 JAN 1984	18:52:33	414	165	7	121	310	76	19	151	6.2
13 JAN 1984	0:54:37	564	71	20	149	491	60	24	151	5.1
13 JAN 1984	0:41:46	359	126	3	40	314	79	19	157	7.5
13 JAN 1984	0:1:45	292	56	27	159	292	56	27	159	8.3
13 JAN 1984	1:39:7	264	42	36	159	264	42	36	159	9.3
13 JAN 1984	2:33:7	313	39	11	45	240	69	22	159	7.2
12 JAN 1984	18:51:58	266	73	4	31	227	48	32	161	7.0
13 JAN 1984	4:40:5	413	99	6	62	239	51	30	161	5.9
13 JAN 1984	4:54:50	489	45	34	161	489	45	34	161	9.0
13 JAN 1984	5:24:12	423	423	1	44	275	73	21	161	5.4
12 JAN 1984	18:33:16	321	41	9	39	160	37	42	163	8.6
12 JAN 1984	21:10:34	396	89	17	159	341	82	19	163	7.0
13 JAN 1984	1:50:43	339	70	9	66	315	49	32	165	7.7
12 JAN 1984	19:0:32	268	44	29	134	179	79	20	166	6.4
12 JAN 1984	18:33:33	326	75	9	71	234	52	31	169	8.3
13 JAN 1984	0:40:48	550	32	22	74	219	44	37	171	7.5
12 JAN 1984	18:56:16	306	44	21	97	203	75	22	173	6.9
13 JAN 1984	2:24:19	406	77	15	121	327	118	14	173	7.2
12 JAN 1984	18:46:57	288	124	13	169	223	69	24	174	6.5
13 JAN 1984	5:40:31	323	44	25	115	162	54	31	176	8.6
13 JAN 1984	5:40:48	363	48	31	156	189	42	41	181	8.4
12 JAN 1984	18:50:41	250	51	29	155	197	51	34	182	7.2
13 JAN 1984	1:50:35	360	50	30	157	178	51	34	182	8.6
12 JAN 1984	18:33:43	256	67	26	183	256	67	26	183	7.4
12 JAN 1984	19:1:26	231	90	19	179	205	99	18	187	6.7
12 JAN 1984	19:2:40	305	50	36	189	305	50	36	189	7.5
12 JAN 1984	18:44:10	334	48	31	156	268	83	22	192	7.4
13 JAN 1984	2:34:32	413	87	10	91	240	63	29	192	7.1
12 JAN 1984	18:44:36	371	49	39	200	371	49	39	200	7.6
12 JAN 1984	19:1:26	391	47	20	99	264	59	33	204	6.4

13 JAN 1984	5:40:12	356	32	21	71	338	66	30	208	9.5
12 JAN 1984	18:56:9	209	36	27	102	189	64	34	228	7.3
12 JAN 1984	18:49:42	347	48	46	232	268	52	44	240	7.1
13 JAN 1984	2:34:4	421	62	39	254	421	62	39	254	6.6
12 JAN 1984	19:39:3	484	57	43	257	484	57	43	257	9.8
13 JAN 1984	2:35:56	440	56	30	176	334	75	34	268	6.7

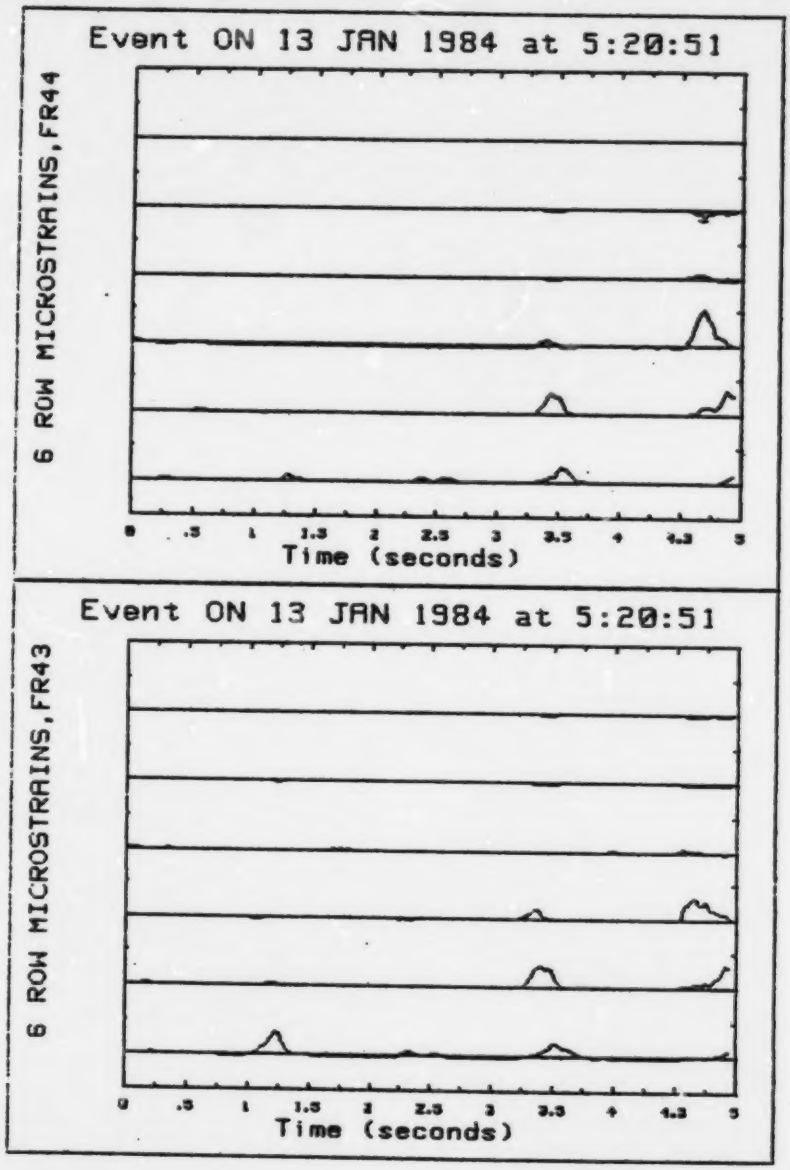
APPENDIX C

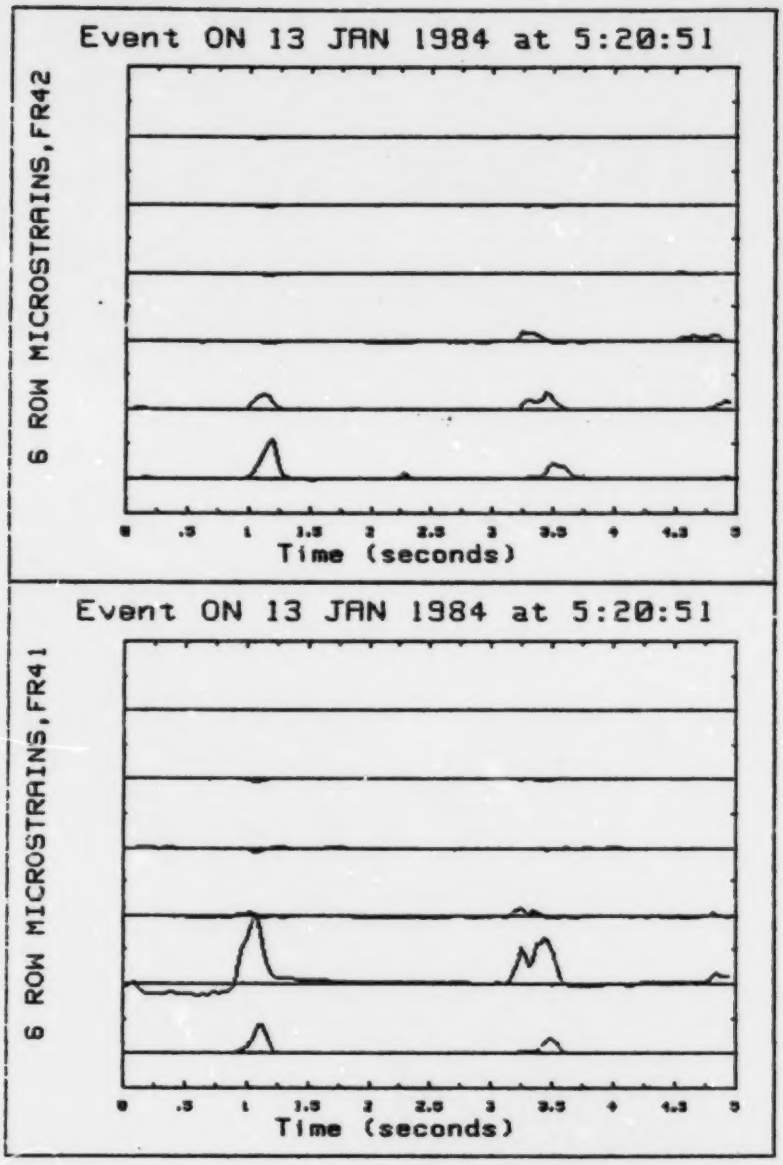
THE FIVE EVENTS OF HIGHEST SINGLE SUB-PANEL PRESSURE

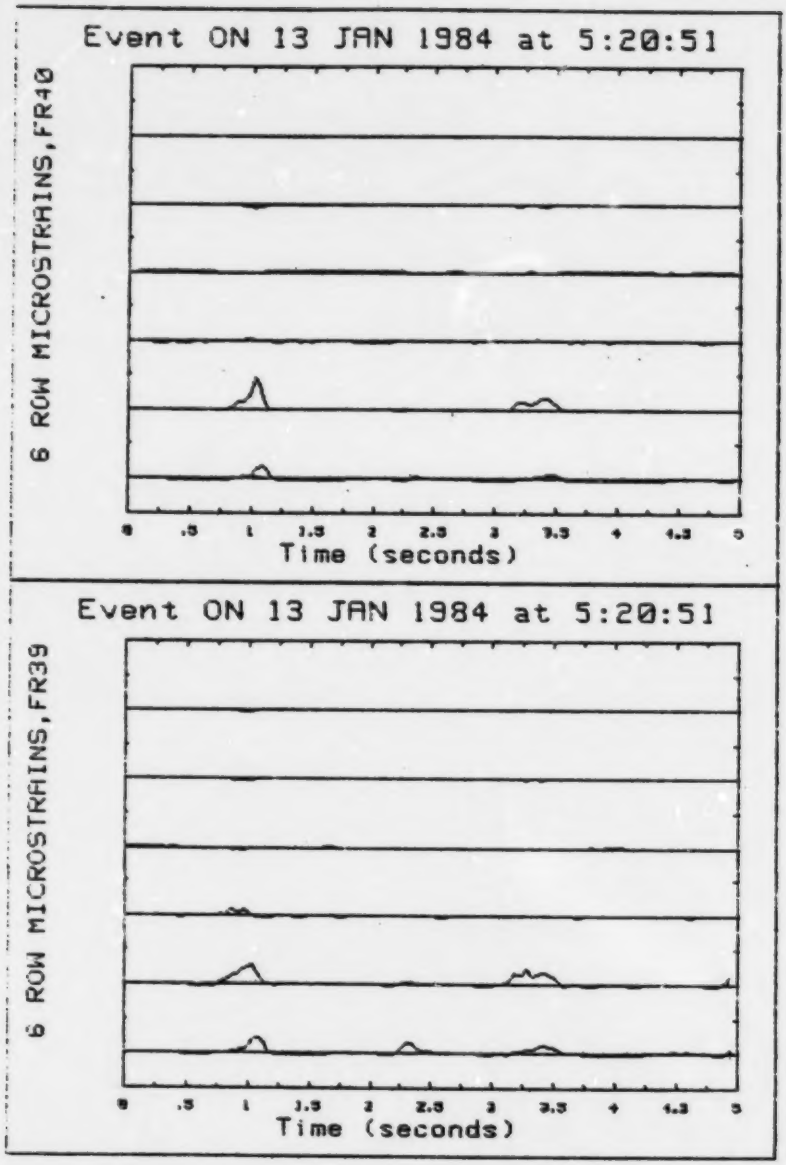
The characteristics of the five events which gave rise to the highest single panel peak pressure have been reproduced herein for the record and future use. This data is of course available for all events.

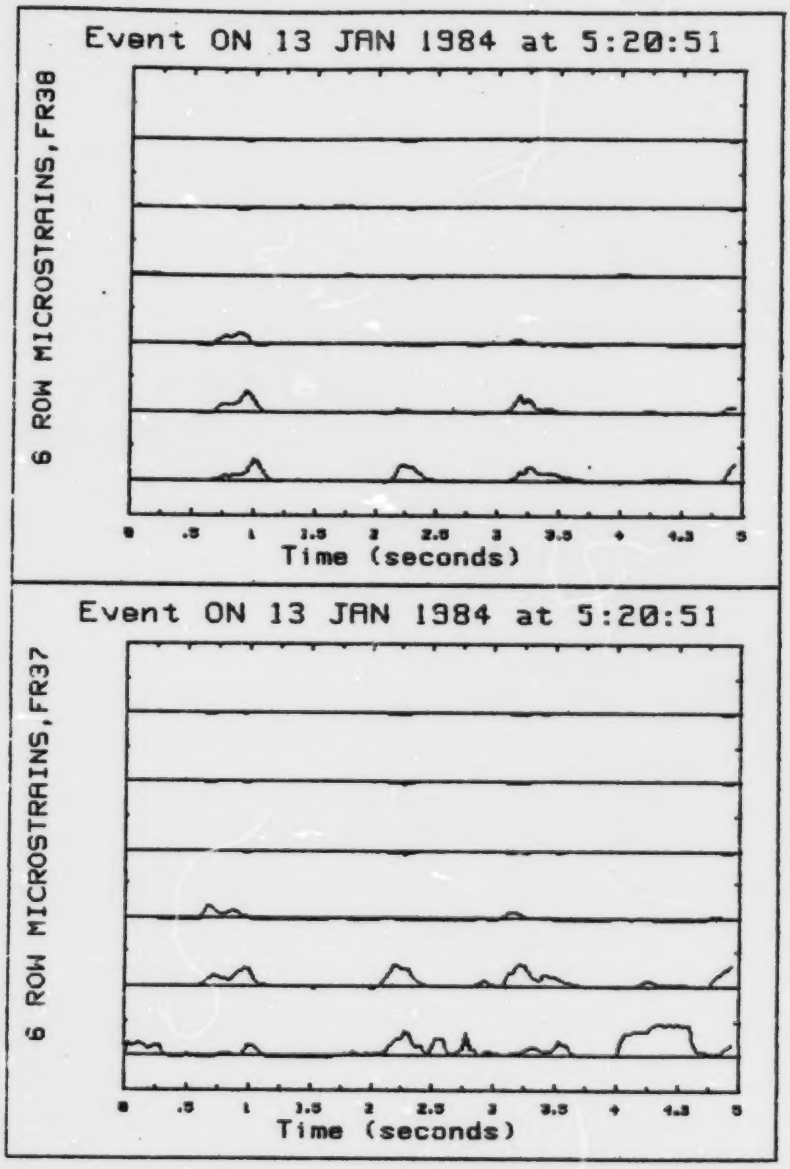
For each event, the time series of strains is presented, as six gauge channels (rows) on each of 10 charts (frames).

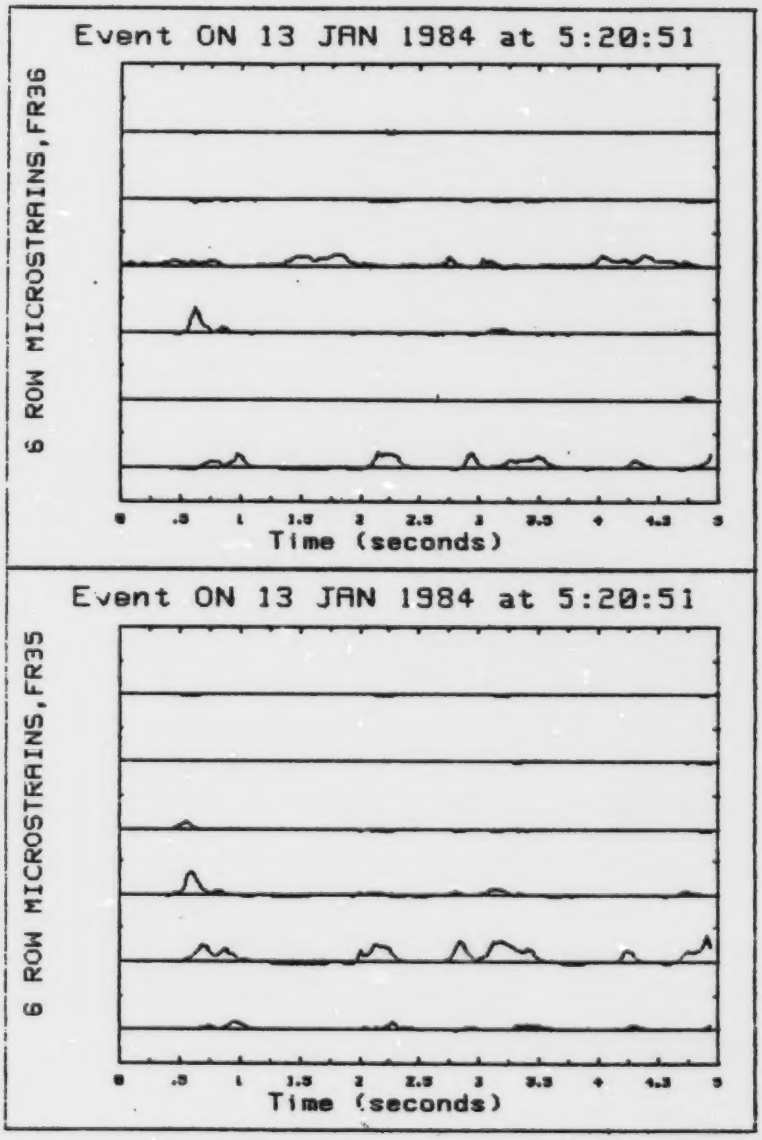
Pressure/area, pressure girth and length distribution data is presented, as well as force and ship motion time histories.

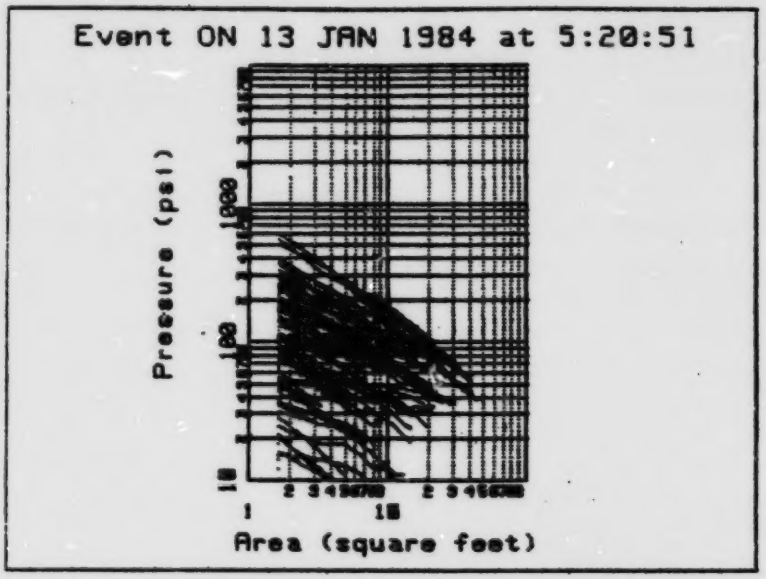

Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR44
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR43
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR42
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR41
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR40
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR39
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR38
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR37
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 13 JAN 1984 at 5:20:51
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 13 JAN 1984 AT 5:20:51
TAPE NUMBER 4 ; TRACK NUMBER 3 ; FILE NUMBER 63
PEAK STRAIN 292 ; THRESHOLD 150
AVERAGE SHIP SPEED 9.30 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 594 PSI; TIME FRAME 34: REAL TIME 1.06
FRAME 41; ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	594.00	375.00	269.00	227.00	199.00	170.00	150.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	136.00	123.00	112.00	110.00	102.00	95.00	88.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	84.00	79.00	74.00	70.00	68.00	66.00	62.00
Area	35.90	37.53					
Pressure	60.00	57.00					

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00
PRESSURE	594.00	302.00	34.00	26.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	594.00	375.00	269.00	206.00	62.00	56.00	51.00
LENGTH	10.67	12.00					
PRESSURE	46.00	42.00					

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 138 LONG TONS; TIME FRAME 34; REAL TIME 1.06
FRAME 41; ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

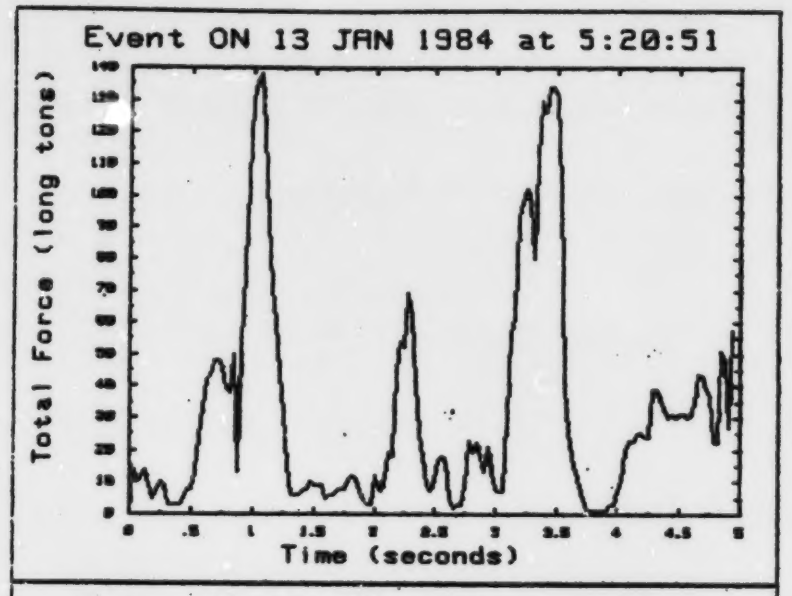
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	594.00	375.00	269.00	227.00	199.00	170.00	150.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	136.00	123.00	112.00	110.00	102.00	95.00	88.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	84.00	79.00	74.00	70.00	68.00	66.00	62.00
Area	35.90	37.53					
Pressure	60.00	57.00					

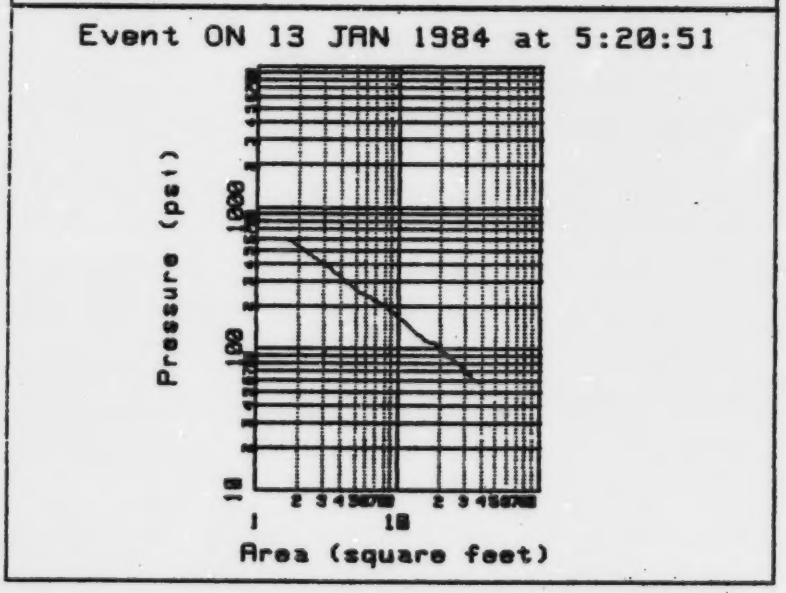
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

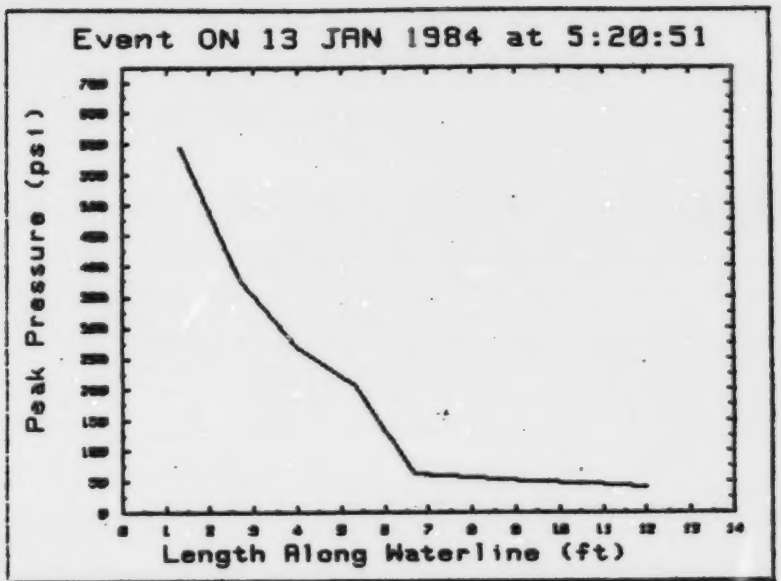
GIRTH	1.25	2.50	3.75	5.00
PRESSURE	594.00	302.00	34.00	26.00

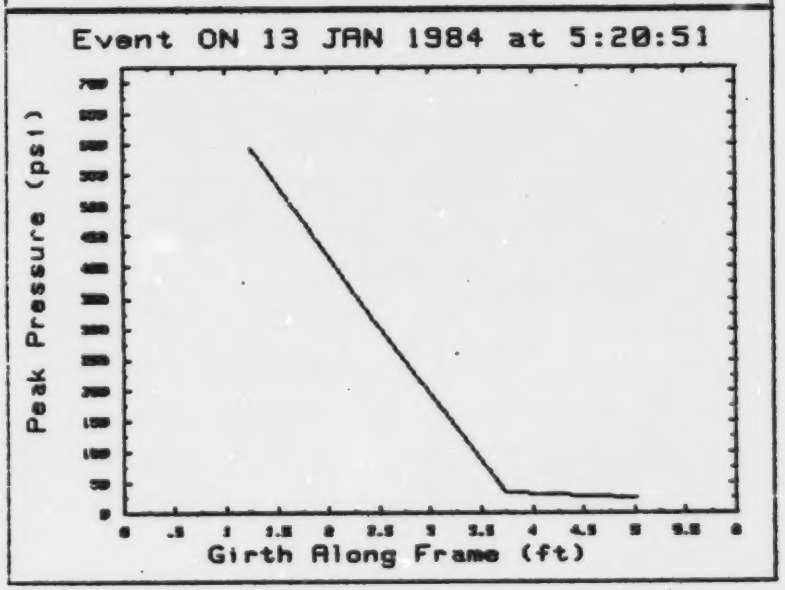
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

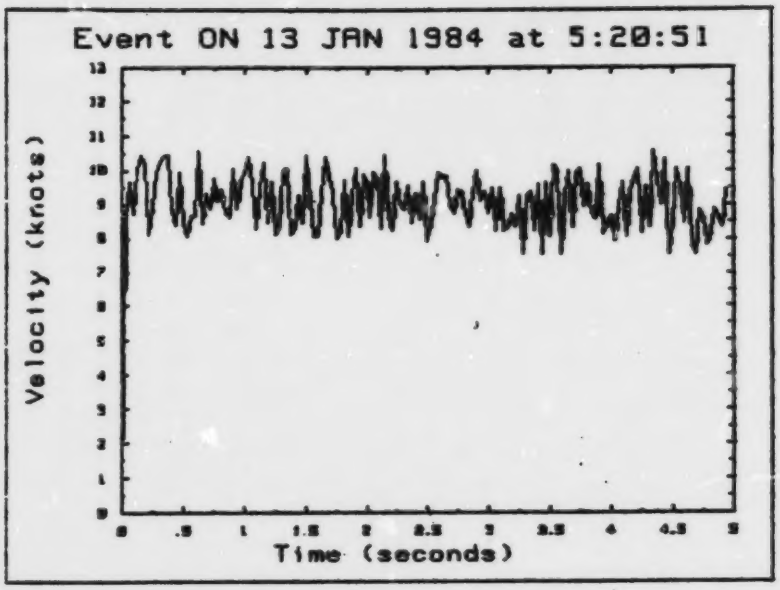
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	594.00	375.00	269.00	206.00	62.00	56.00	51.00
LENGTH	10.67	12.00					
PRESSURE	46.00	42.00					


Event ON 13 JAN 1984 at 5:20:51
Total Force (long tons)
Time (seconds)


Event ON 13 JAN 1984 at 5:20:51
Pressure (psi)
Area (square feet)

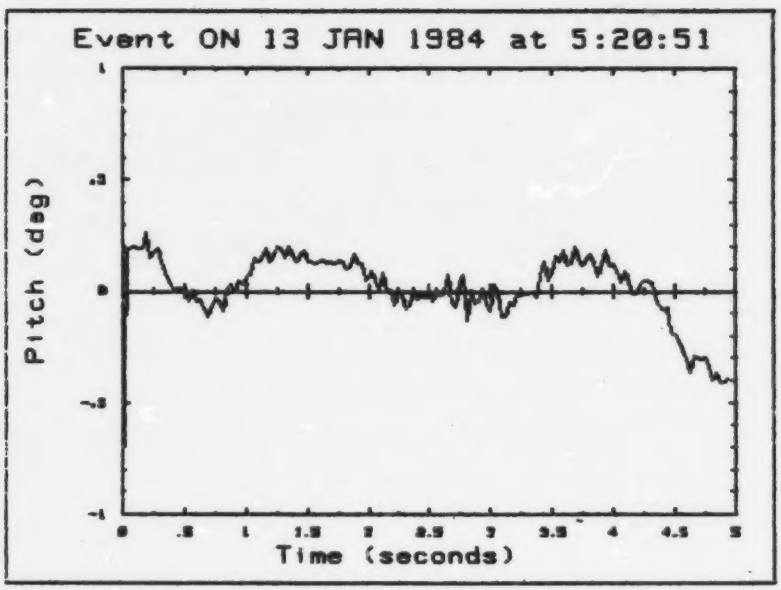

Event ON 13 JAN 1984 at 5:20:51
Peak Pressure (psi)
Length Along Waterline (ft)

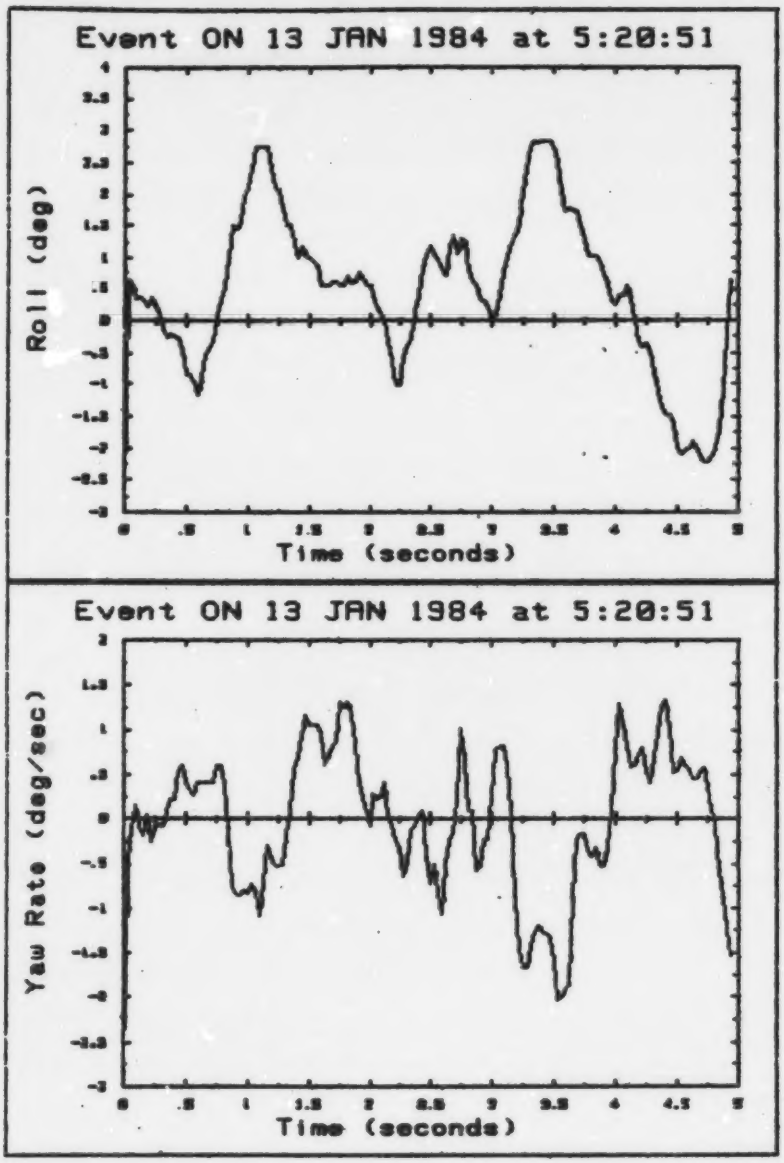

Event ON 13 JAN 1984 at 5:20:51
Peak Pressure (psi)
Girth Along Frame (ft)

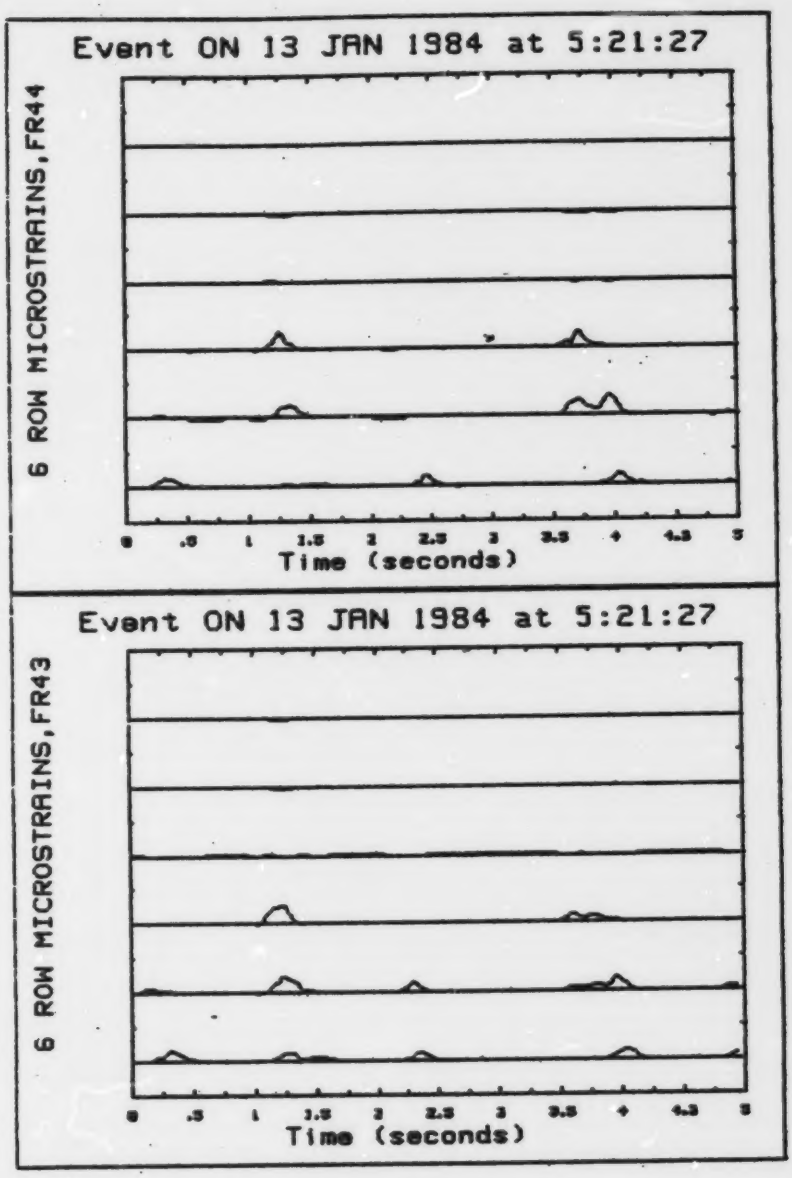

Event ON 13 JAN 1984 at 5:20:51
Velocity (knots)
Time (seconds)

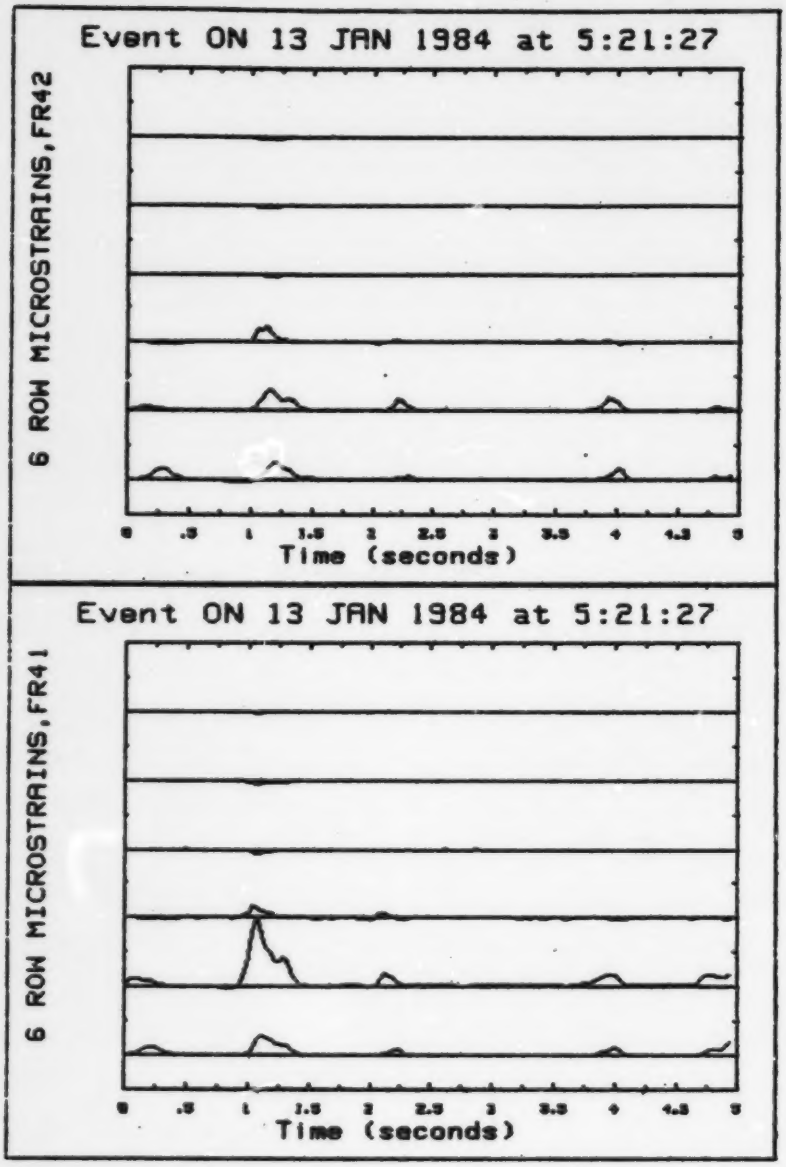
AVERAGE PITCH	0.00	Deg Bow Up
AVERAGE ROLL	.45	Deg To Starboard
AVERAGE YAW RATE	.33	Deg/Sec Bow To Starboard

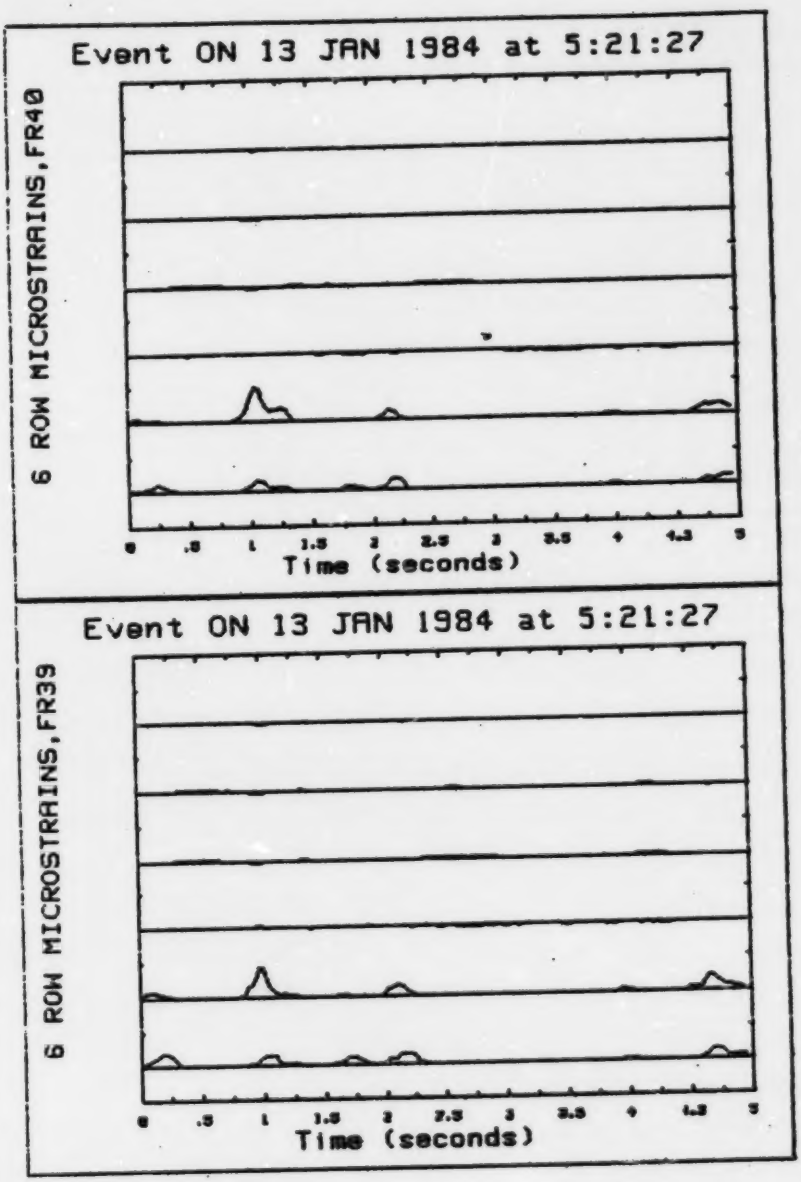
ZERO(1) =	1784	ZERO(2) =	2072
ZERO(3) =	3509	ZERO(4) =	3002

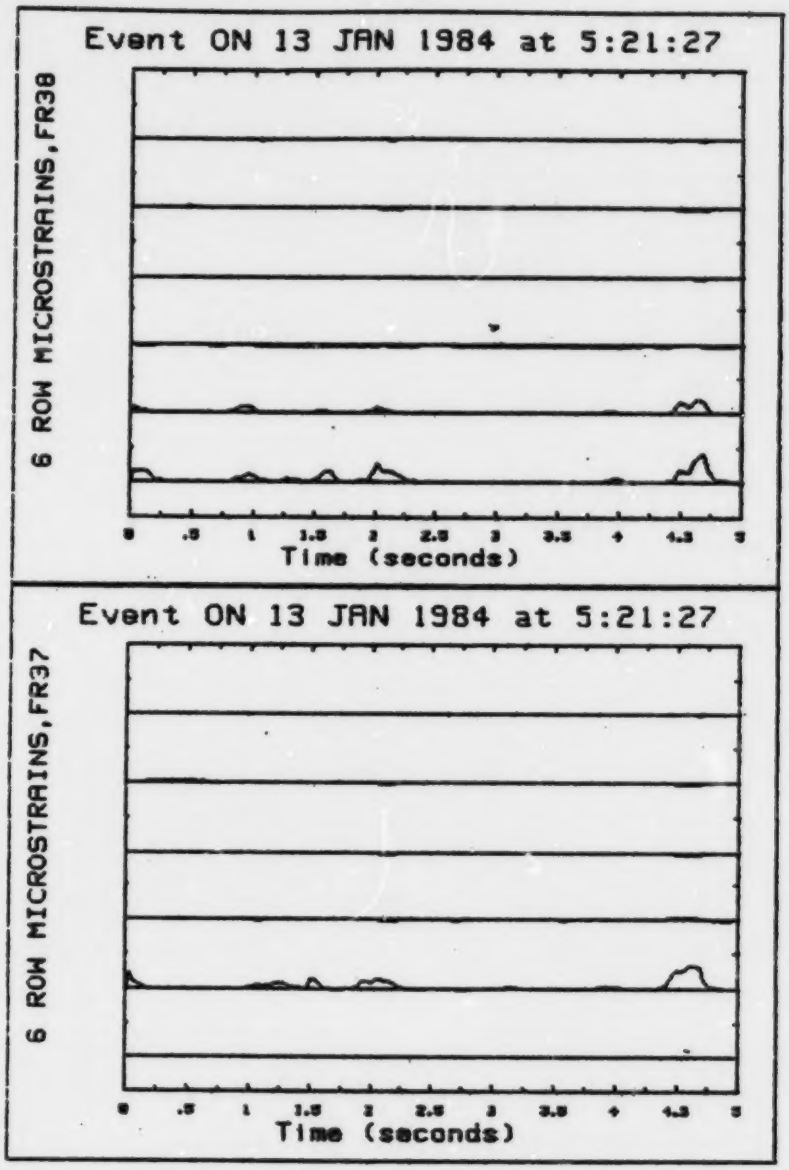


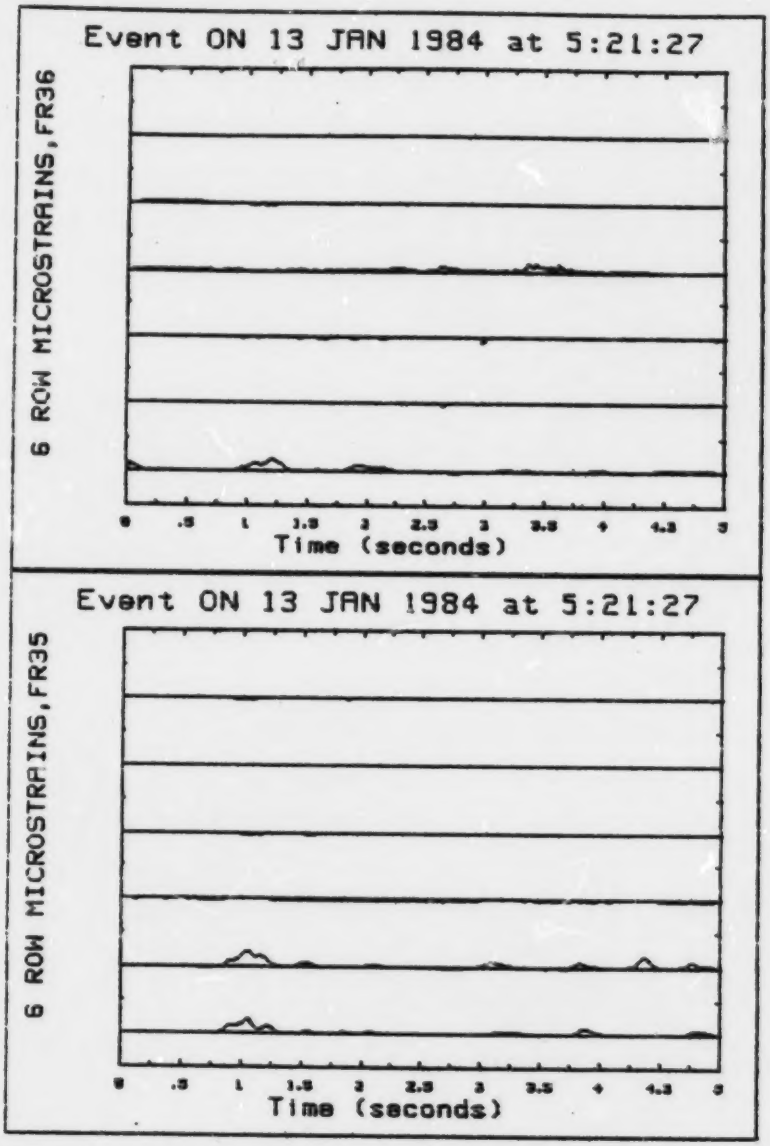

Event ON 13 JAN 1984 at 5:20:51
Roll (deg)
Time (seconds)
Event ON 13 JAN 1984 at 5:20:51
Yaw Rate (deg/sec)
Time (seconds)

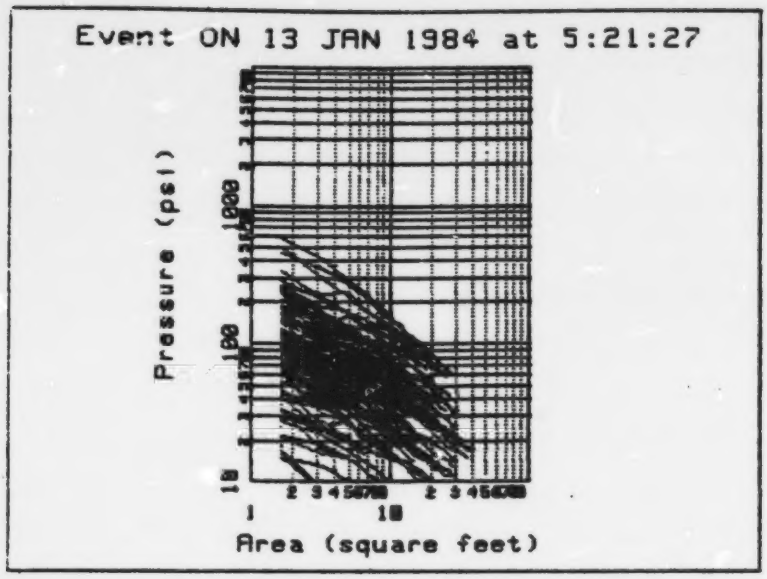

Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR44
Time (seconds)
Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR43
Time (seconds)


Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 13 JAN 1984 at 5:21:27
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 13 JAN 1984 AT 5:21:27
TAPE NUMBER 4 : TRACK NUMBER 3 ; FILE NUMBER 65
PEAK STRAIN 294 ; THRESHOLD 150
AVERAGE SHIP SPEED 6.11 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 589 PSI; TIME FRAME 34; REAL TIME 1.06
FRAME 41: ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	589.00	412.00	289.00	234.00	191.00	162.00	139.00

Area	13.06	14.69	16.32	17.95
Pressure	122.00	109.00	100.00	91.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	589.00	127.00	39.00	29.00	24.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00
PRESSURE	589.00	412.00	289.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 107 LONG TONS; TIME FRAME 33; REAL TIME 1.03
FRAME 41; ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

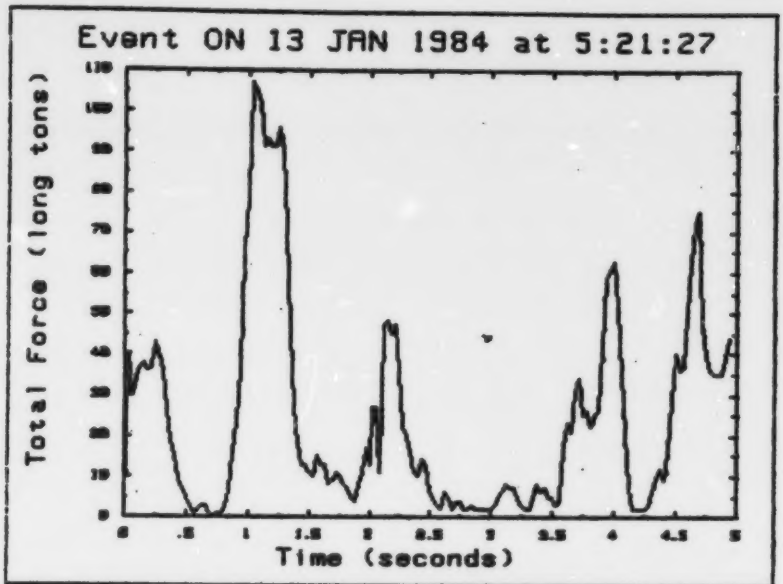
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	447.00	357.00	277.00	219.00	180.00	154.00	141.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	124.00	110.00	100.00	92.00	84.00	78.00	72.00
Area	24.48	26.11	27.74				
Pressure	68.00	64.00	60.00				

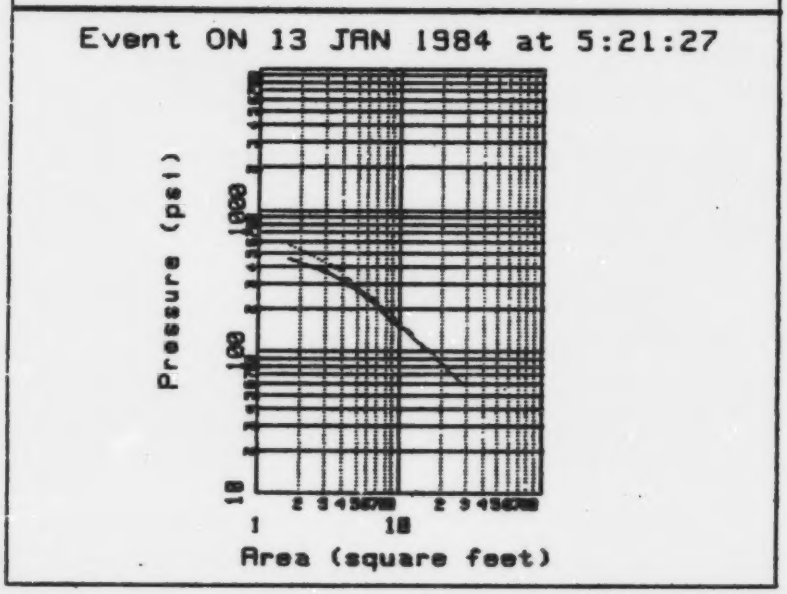
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

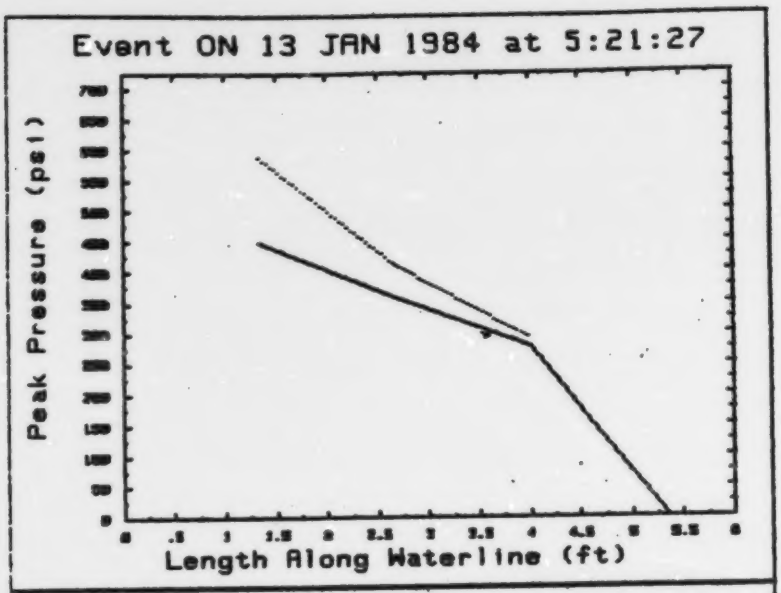
GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	447.00	236.00	159.00	120.00	98.00

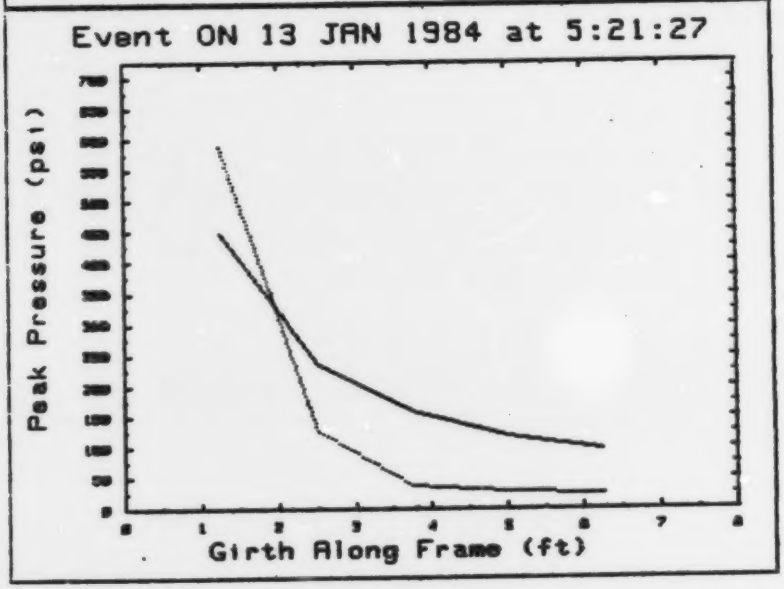
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

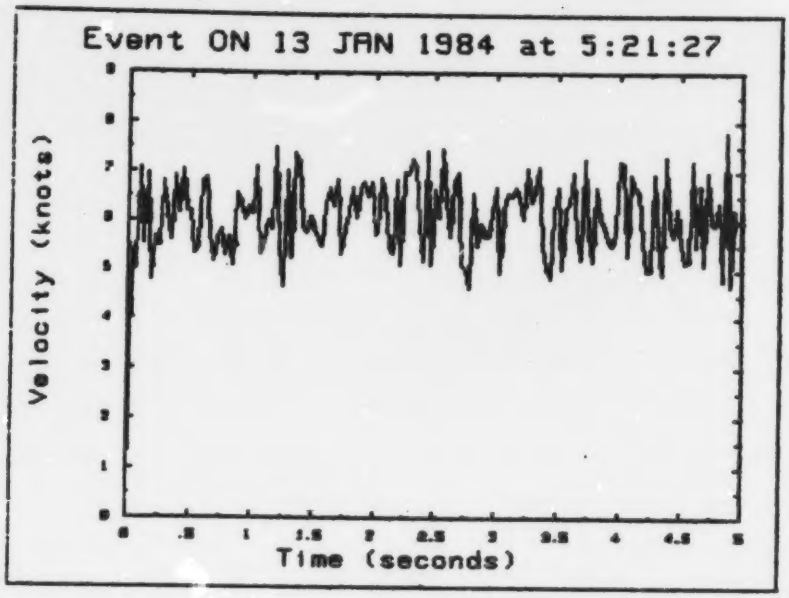
LENGTH	1.33	2.67	4.00	5.33
PRESSURE	447.00	357.00	277.00	3.00


Event ON 13 JAN 1984 at 5:21:27
Total Force (long tons)
Time (seconds)


Event ON 13 JAN 1984 at 5:21:27
Pressure (psi)
Area (square feet)

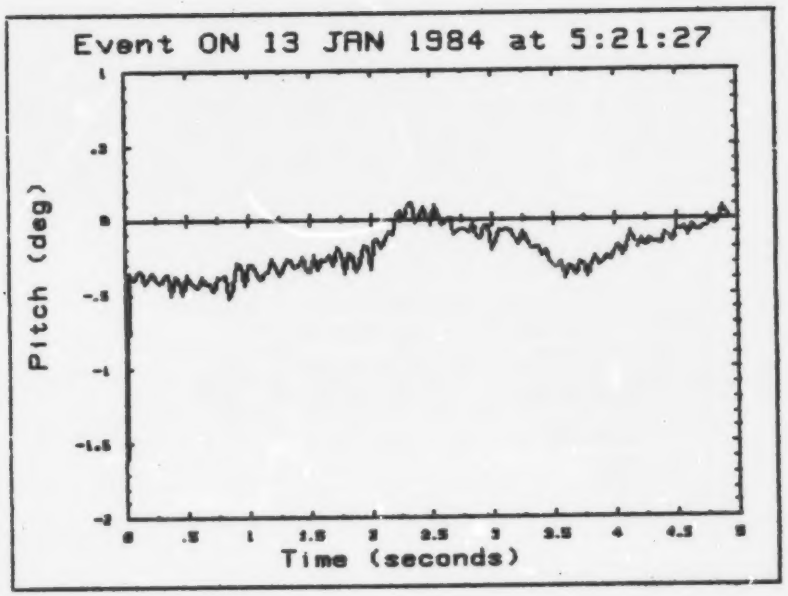

Event ON 13 JAN 1984 at 5:21:27
Peak Pressure (psi)
Length Along Waterline (ft)

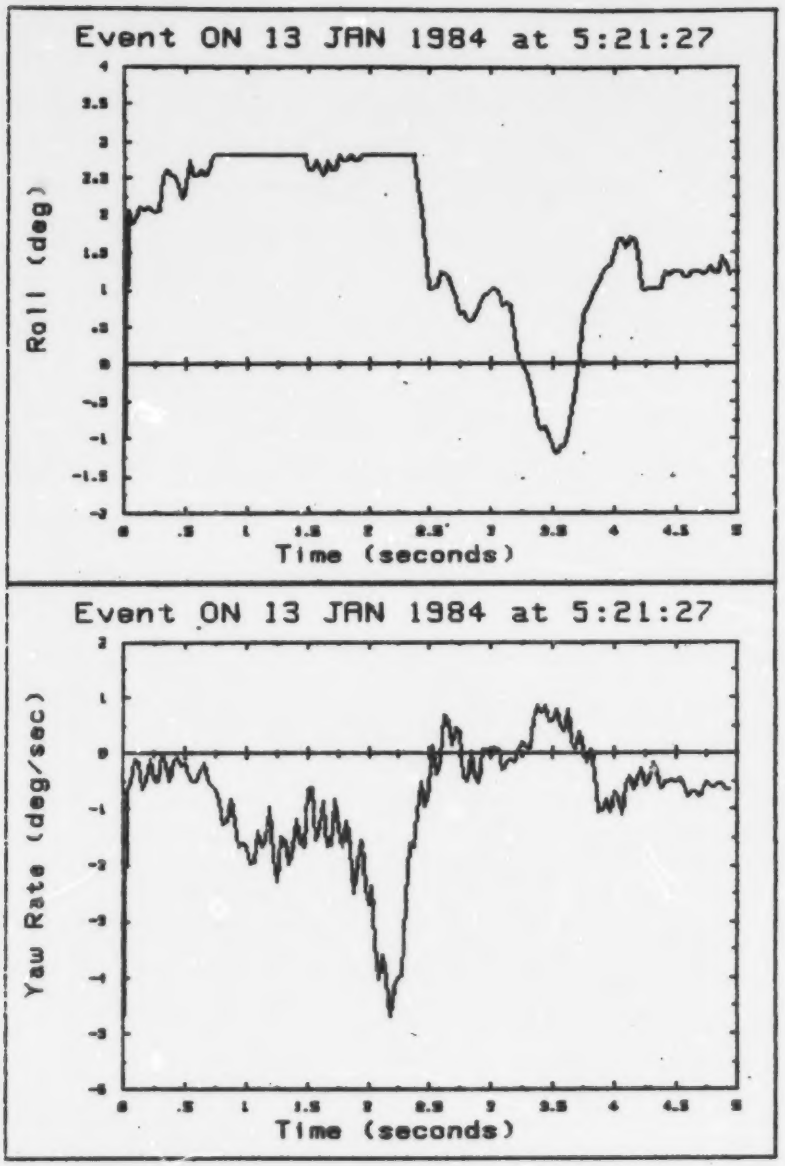

Event ON 13 JAN 1984 at 5:21:27
Peak Pressure (psi)
Girth Along Frame (ft)

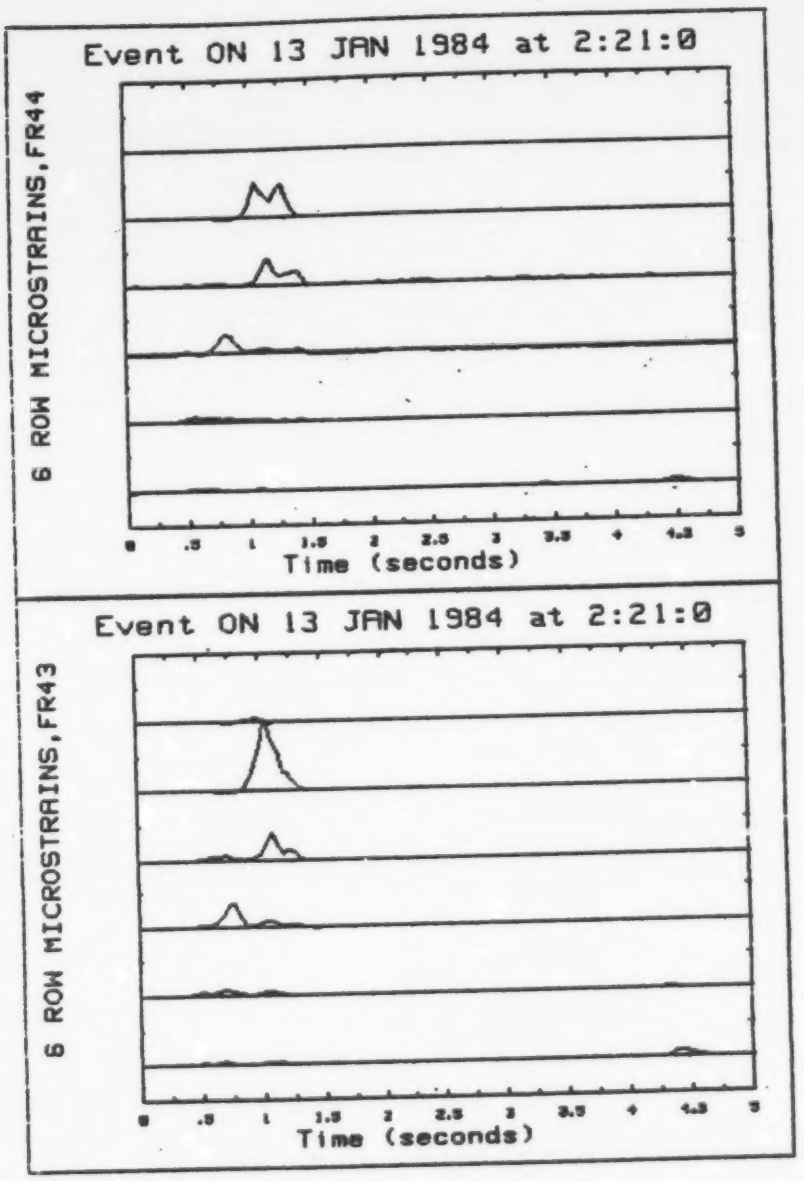

Event ON 13 JAN 1984 at 5:21:27
Velocity (knots)
Time (seconds)

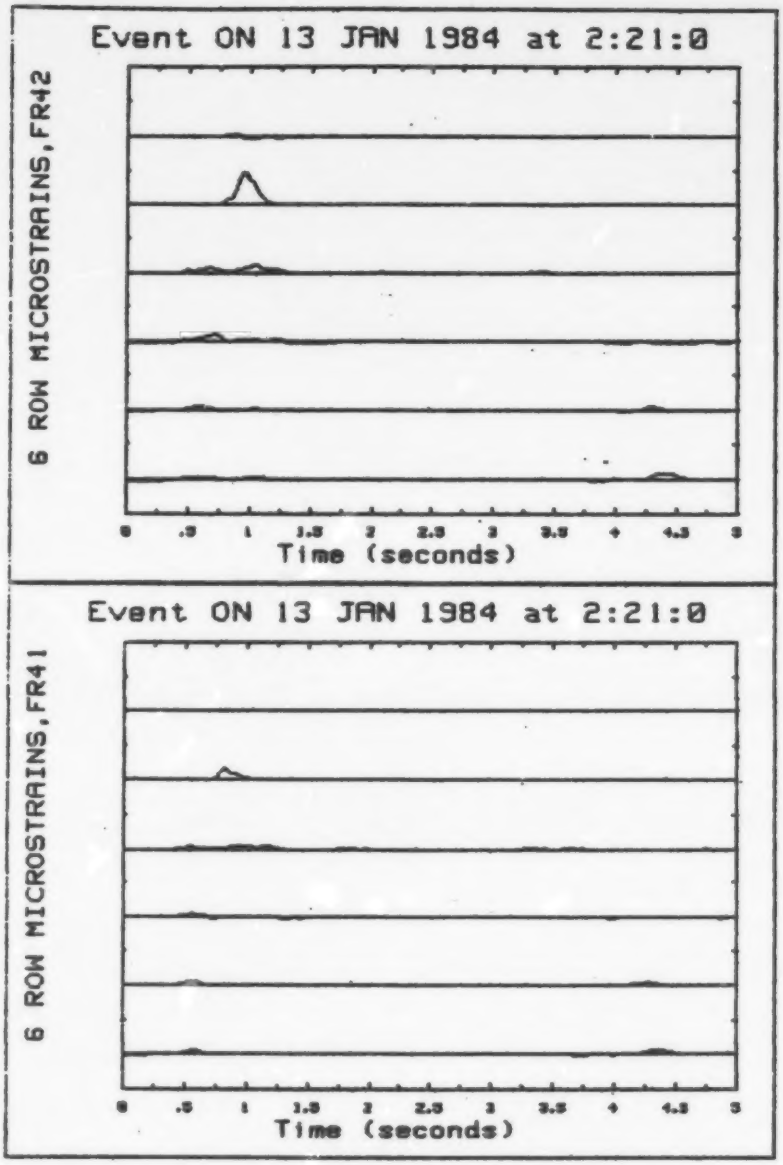
AVERAGE PITCH	.42	Deg Bow Down
AVERAGE ROLL	2.53	Deg To Port
AVERAGE YAW RATE	.33	Deg/Sec Bow To Port

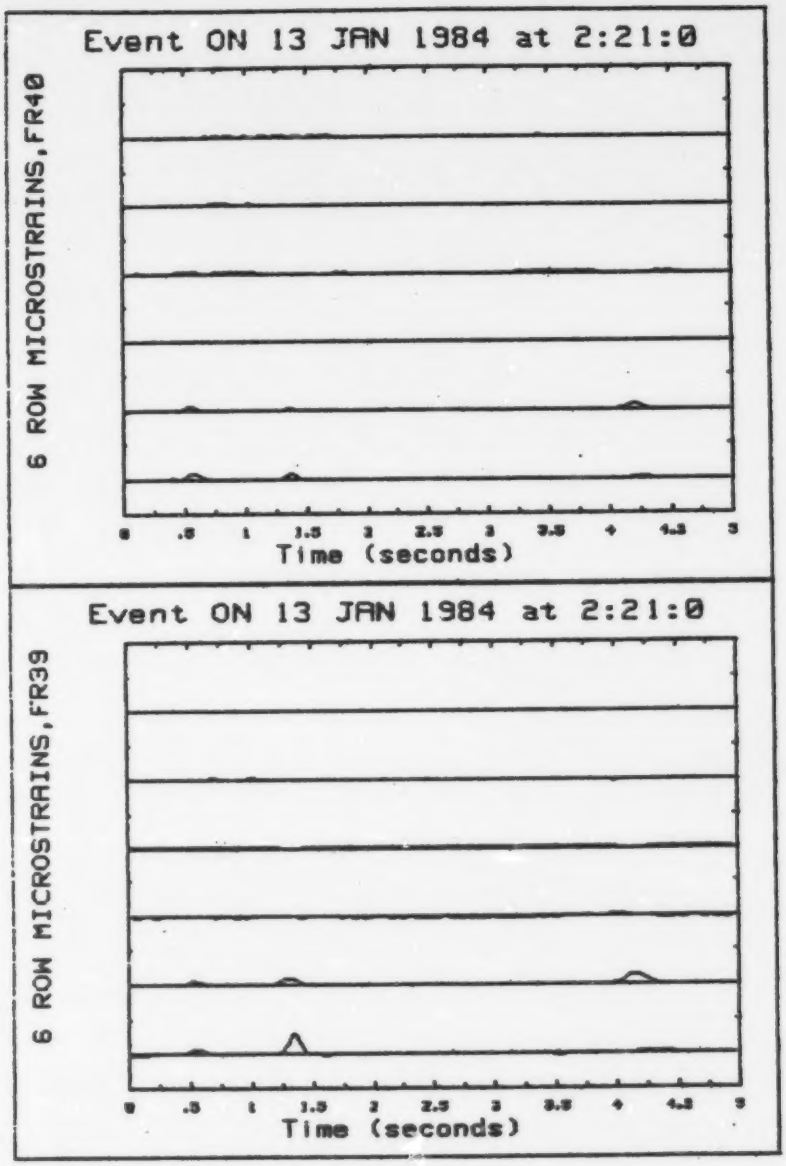
ZERO(1) =	1784	ZERO(2) =	2072
ZERO(3) =	3509	ZERO(4) =	3002

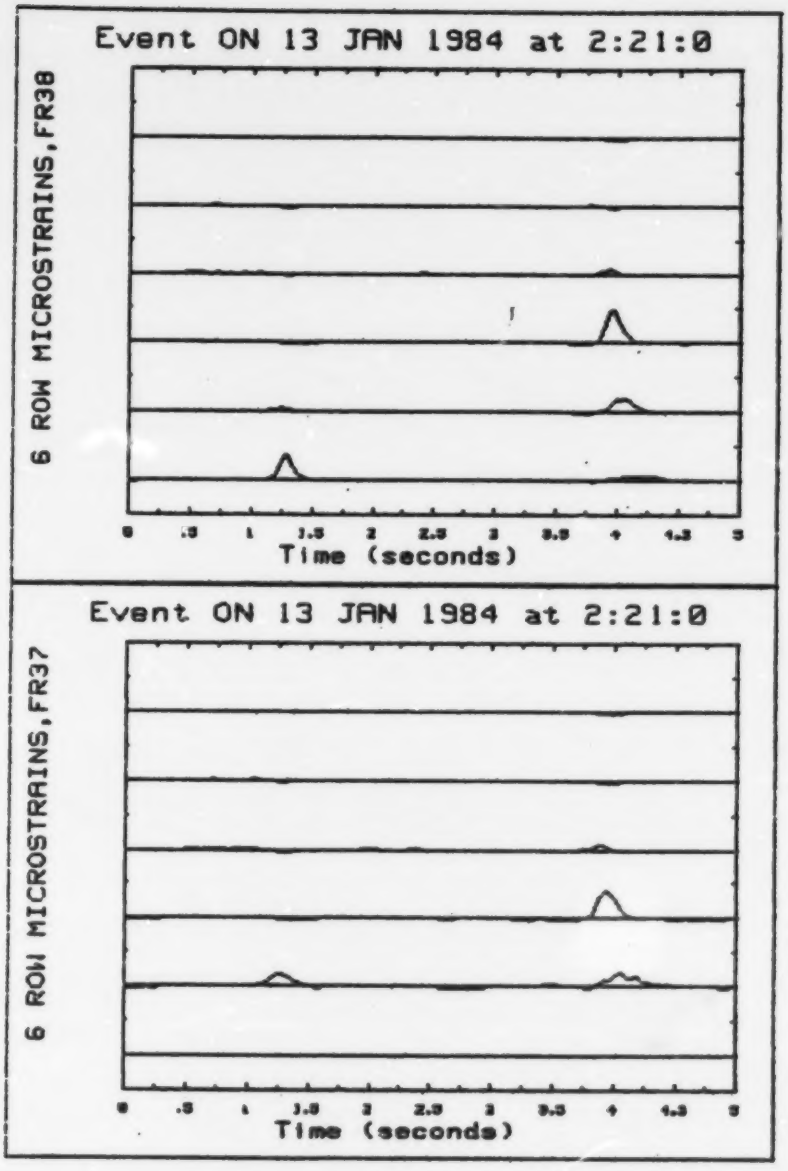


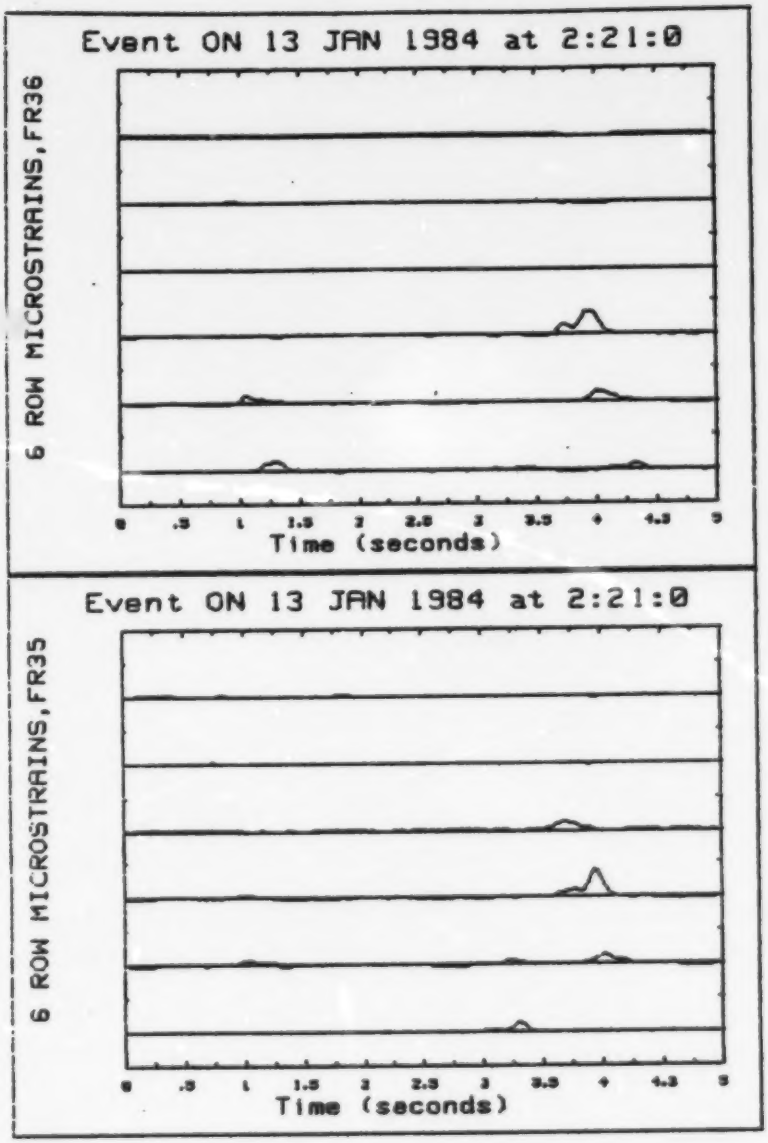

Event ON 13 JAN 1984 at 5:21:27
Roll (deg)
Time (seconds)
Event ON 13 JAN 1984 at 5:21:27
Yaw Rate (deg/sec)
Time (seconds)

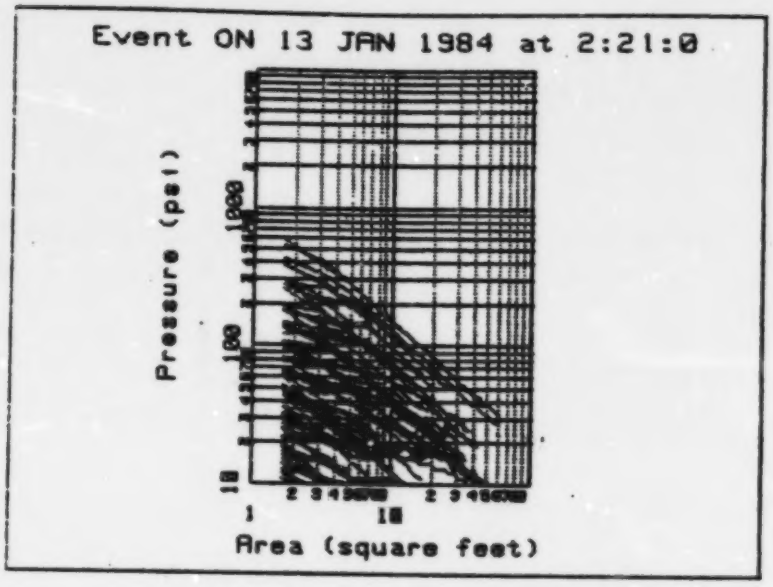

Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR44
Time (seconds)
Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR43
Time (seconds)


Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 13 JAN 1984 at 2:21:0
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 13 JAN 1984 AT 2:21:0
TAPE NUMBER 4 ; TRACK NUMBER 3 ; FILE NUMBER 13
PEAK STRAIN 225 ; THRESHOLD 150
AVERAGE SHIP SPEED 6.55 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 588 PSI; TIME FRAME 33; REAL TIME 1.03
FRAME 43; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	588.00	367.00	286.00	224.00	182.00	155.00	134.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	121.00	109.00	99.00	91.00	84.00	78.00	73.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	68.00	64.00	60.00	57.00	54.00	52.00	50.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	48.00	46.00	44.00	42.00	41.00	39.00	38.00
Area	47.33						
Pressure	37.00						

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	588.00	312.00	51.00	39.00	33.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67
PRESSURE	588.00	367.00	286.00	14.00	6.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 120 LONG TONS; TIME FRAME 34; REAL TIME 1.06
FRAME 43; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

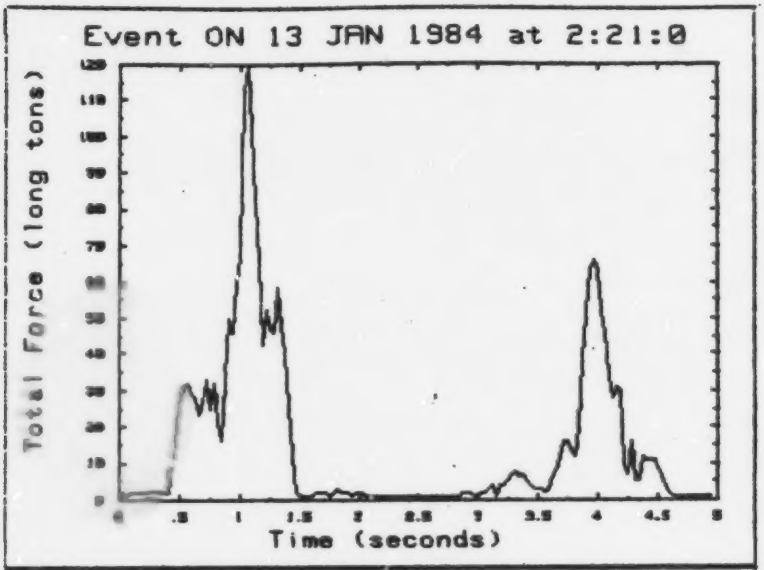
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	528.00	401.00	282.00	219.00	181.00	154.00	135.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	121.00	109.00	99.00	90.00	83.00	77.00	73.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	68.00	64.00	61.00	58.00	55.00	52.00	50.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	48.00	46.00	44.00	44.00	43.00	42.00	40.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	39.00	38.00	37.00	36.00	35.00	34.00	33.00
Area	58.75	60.38					
Pressure	32.00	31.00					

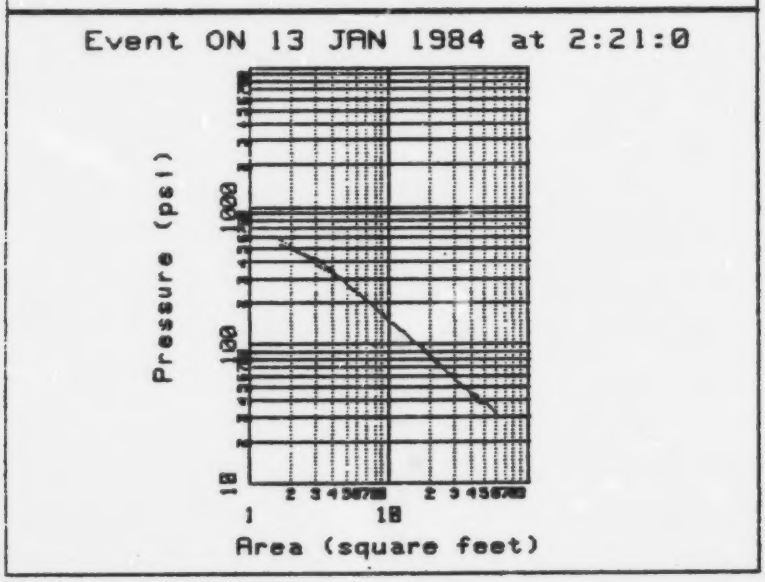
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

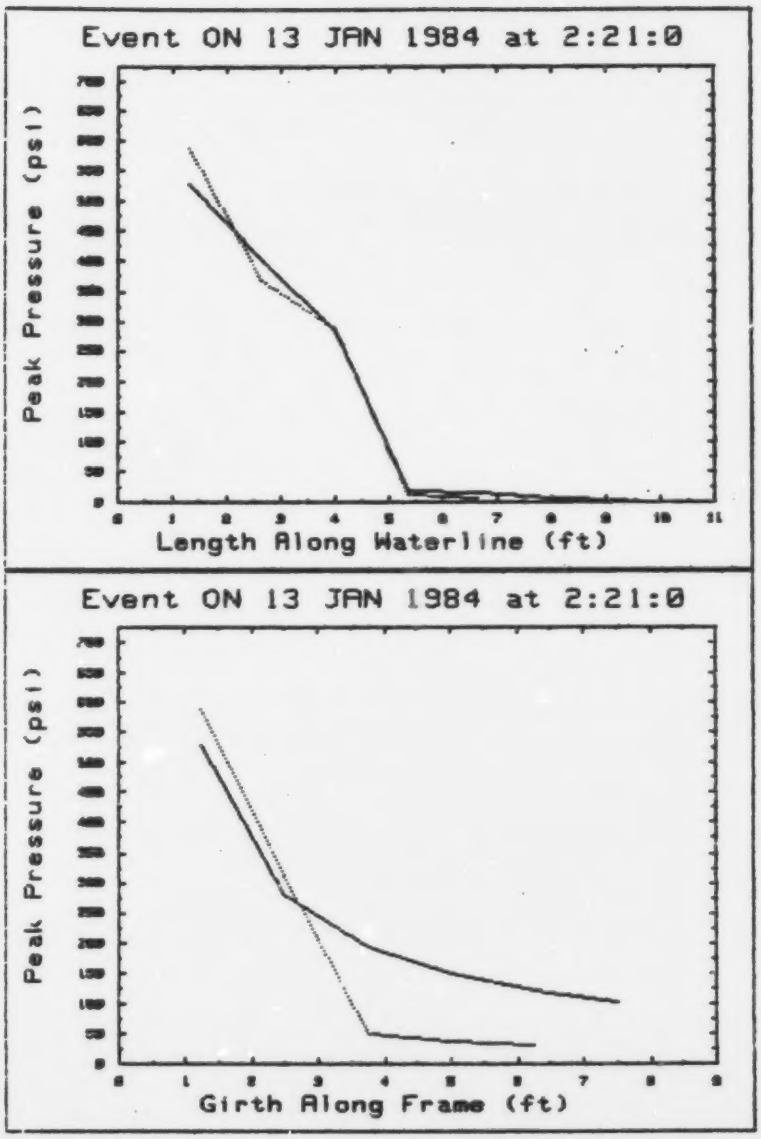
GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	528.00	280.00	194.00	151.00	122.00	103.00

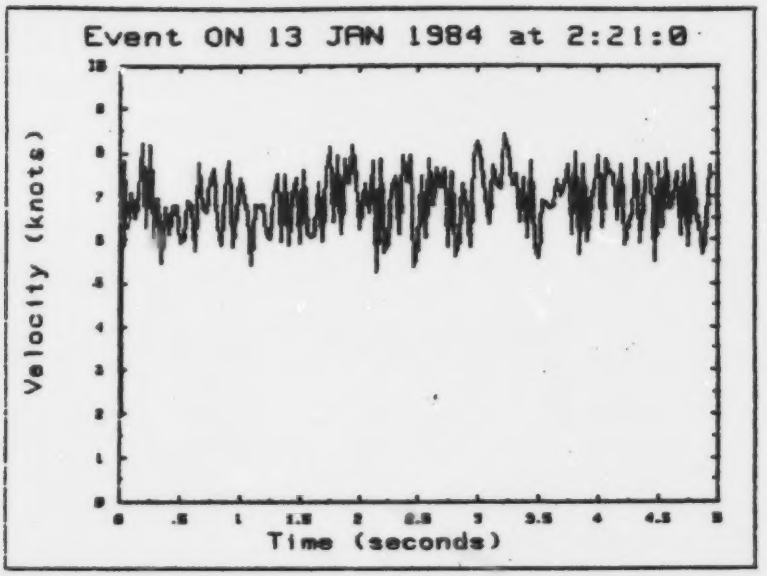
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	528.00	401.00	282.00	19.00	16.00	6.00	5.00


Event ON 13 JAN 1984 at 2:21:0
Total Force (long tons)
Time (seconds)

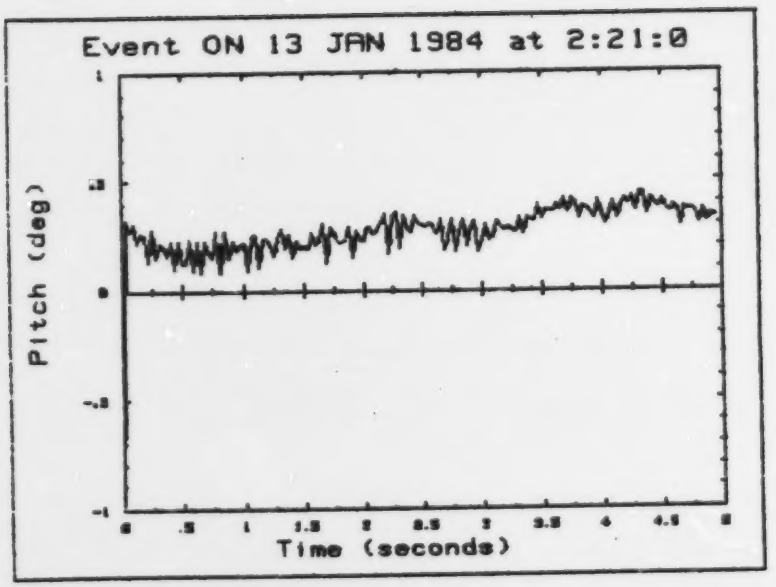

Event ON 13 JAN 1984 at 2:21:0
Pressure (psi)
Area (square feet)

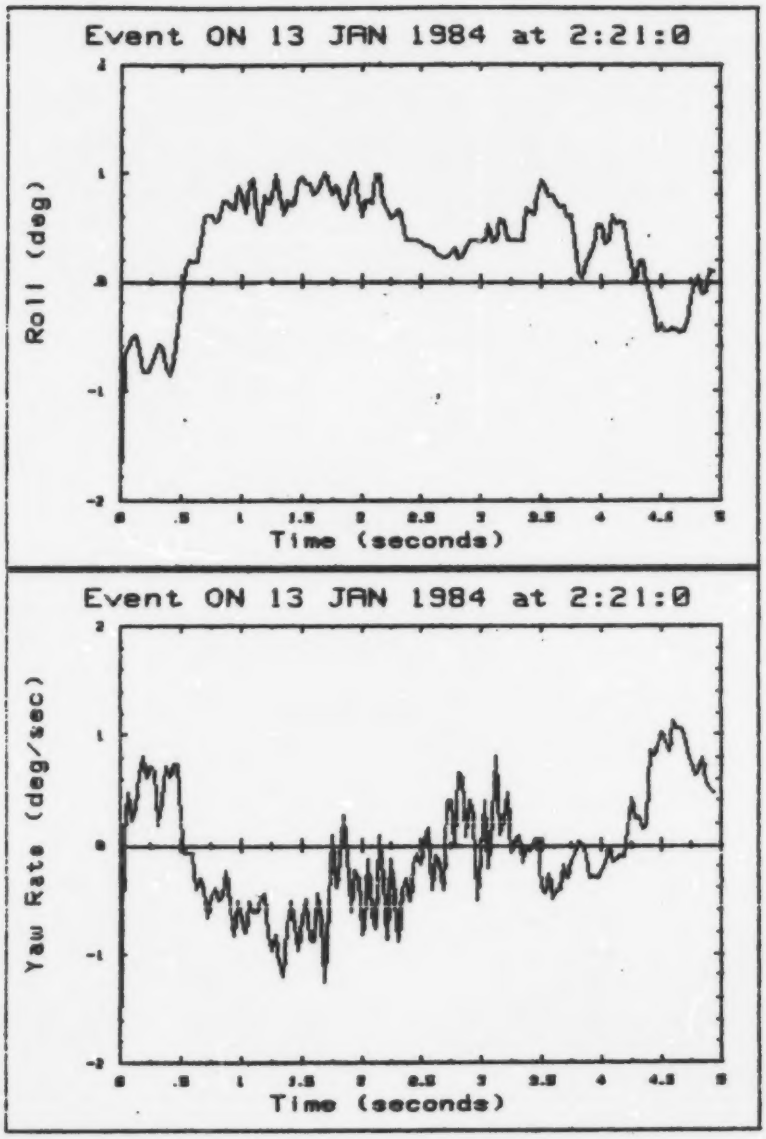

Event ON 13 JAN 1984 at 2:21:0
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 13 JAN 1984 at 2:21:0
Peak Pressure (psi)
Girth Along Frame (ft)

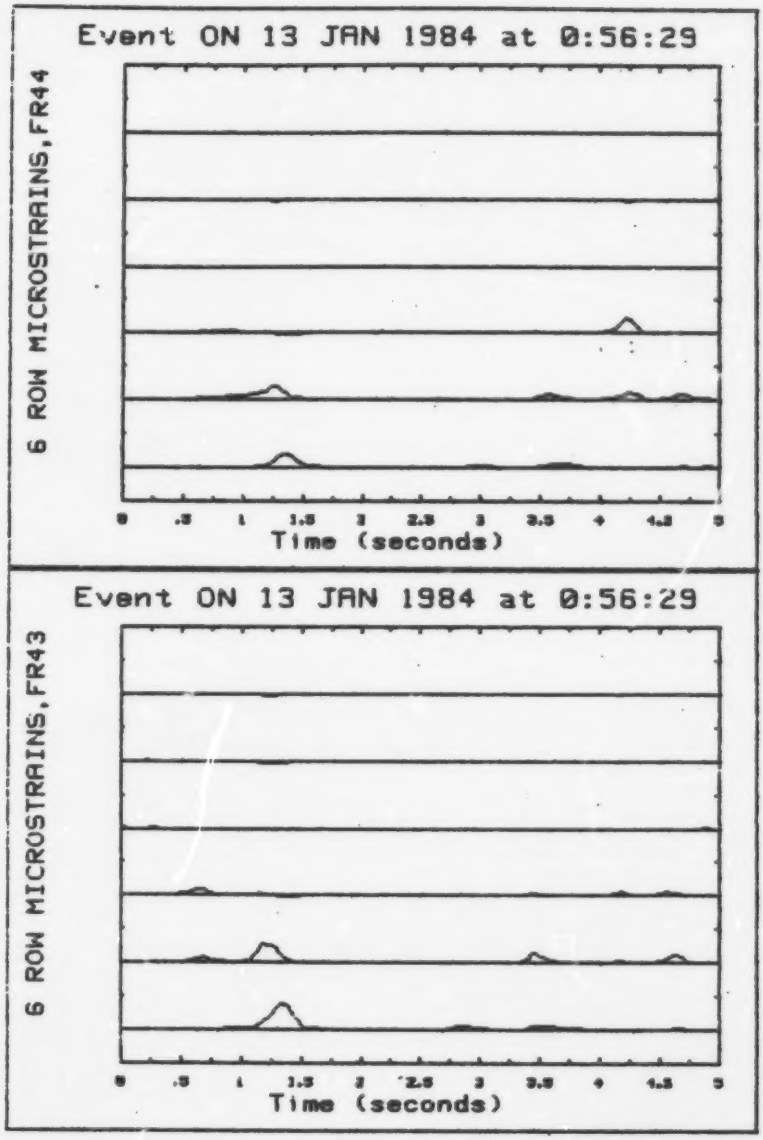

Event ON 13 JAN 1984 at 2:21:0
Velocity (knots)
Time (seconds)

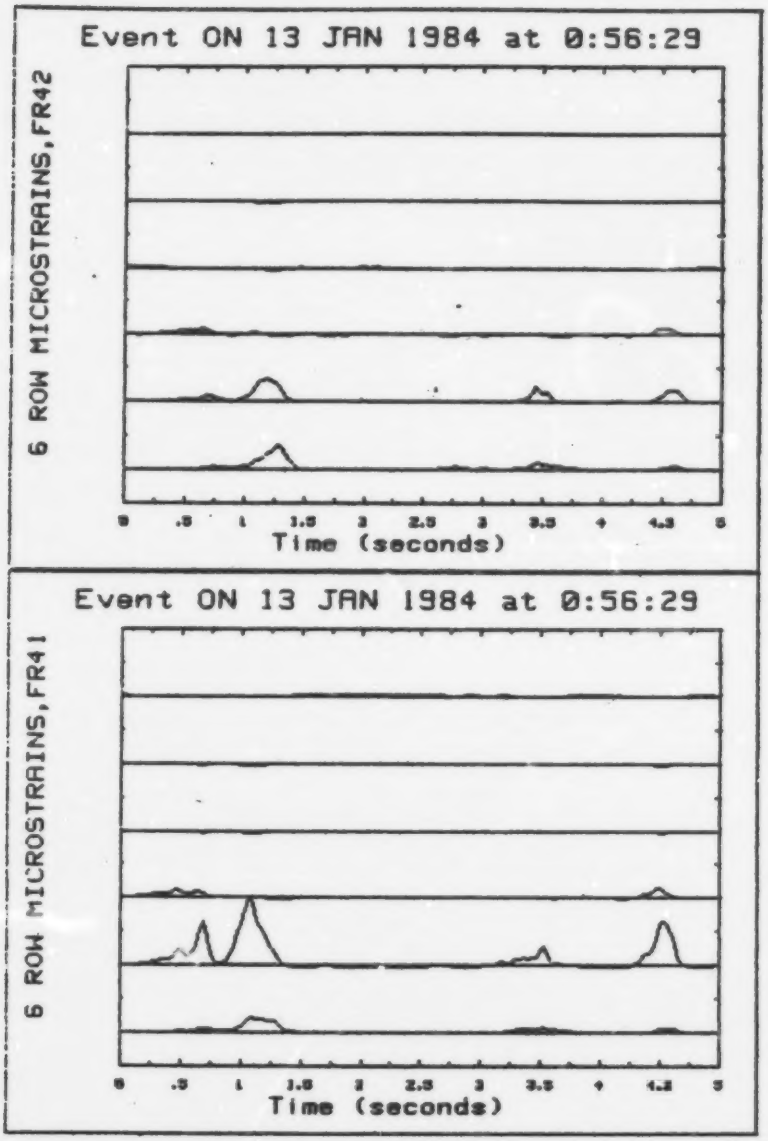
AVERAGE PITCH .17 Deg Bow Up
AVERAGE ROLL .12 Deg To Starboard
AVERAGE YAW RATE .11 Deg/Sec Bow To Starboard

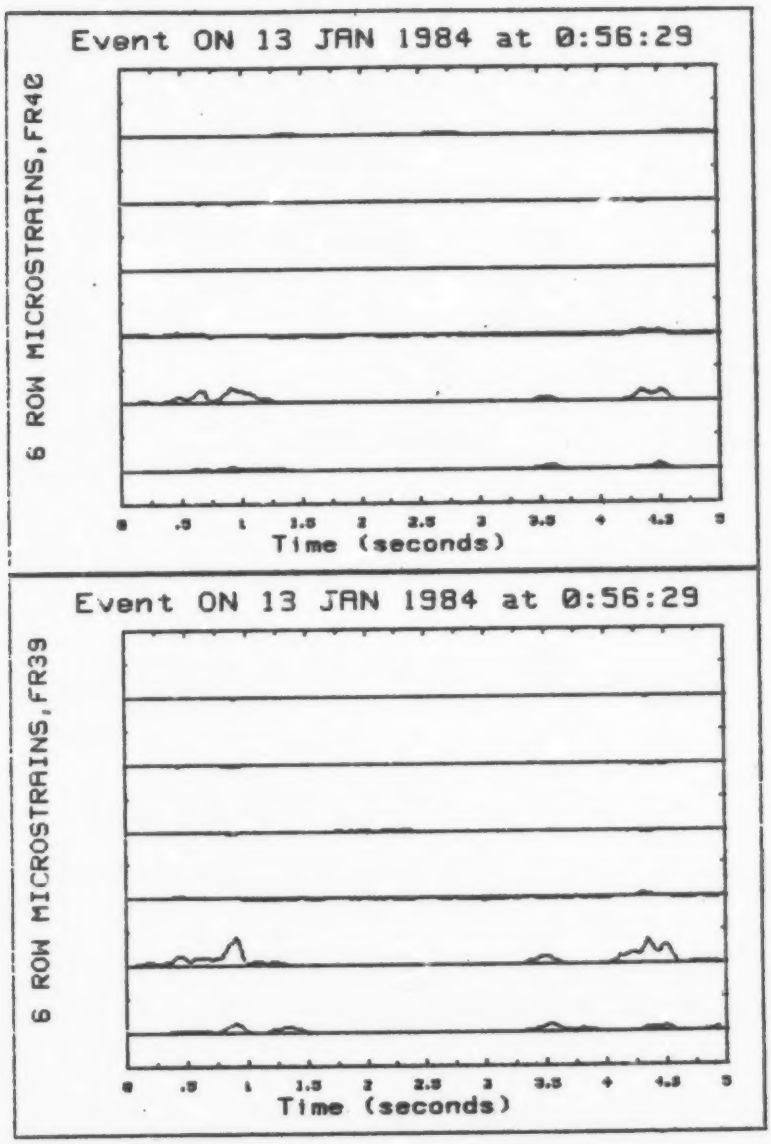
ZERO(1) = 1784 ZERO(2) = 2072
ZERO(3) = 3509 ZERO(4) = 3002

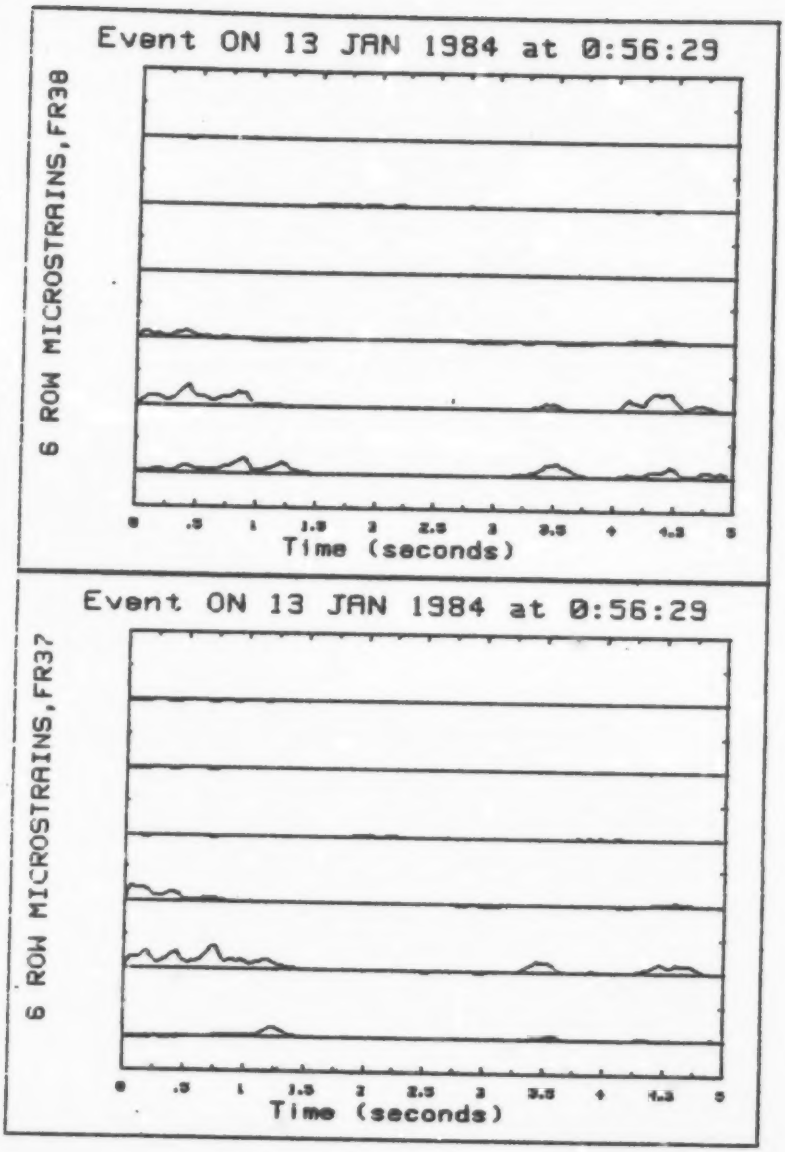


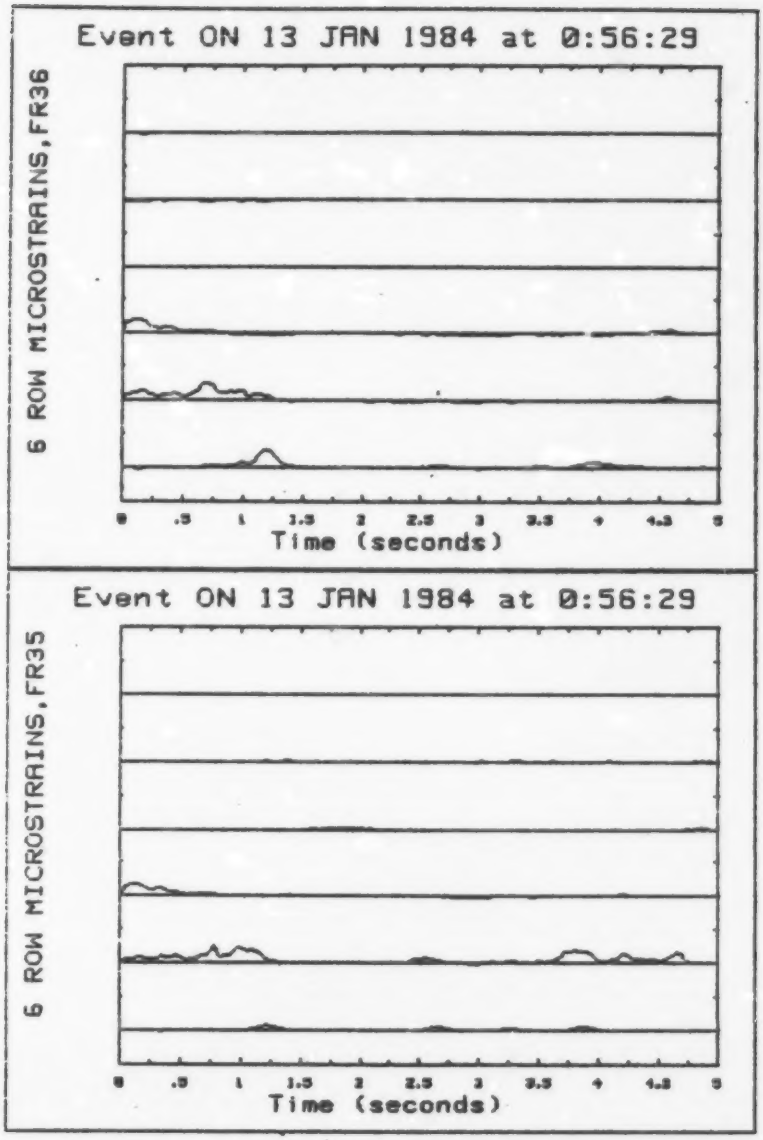

Event ON 13 JAN 1984 at 2:21:0
Roll (deg)
Time (seconds)
Event ON 13 JAN 1984 at 2:21:0
Yaw Rate (deg/sec)
Time (seconds)

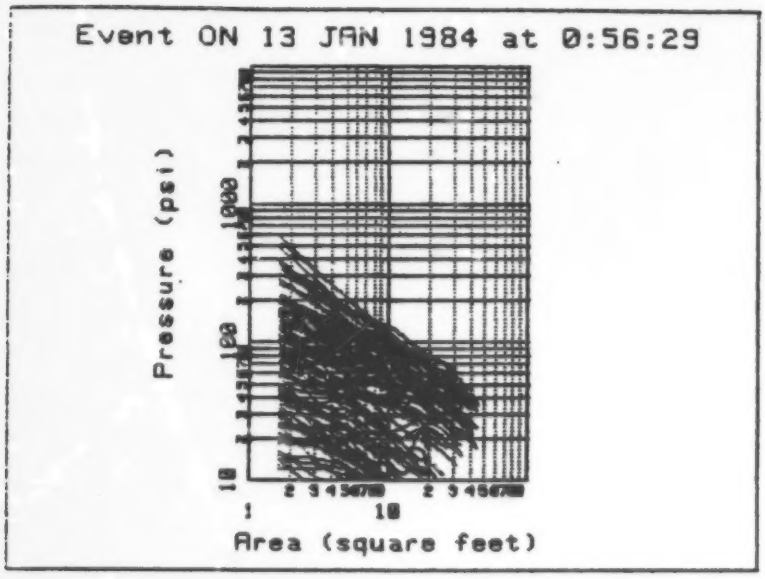

Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR44
Time (seconds)
Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR43
Time (seconds)


Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR40
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR39
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS, FR38
Time (seconds)
Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS, FR37
Time (seconds)


Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 13 JAN 1984 at 0:56:29
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 13 JAN 1984 AT 0:56:29
TAPE NUMBER 4 ; TRACK NUMBER 2 ; FILE NUMBER 49
PEAK STRAIN 271 ; THRESHOLD 150
AVERAGE SHIP SPEED 3.47 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 582 PSI: TIME FRAME 34; REAL TIME 1.06
FRAME 41: ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	582.00	303.00	211.00	160.00	135.00	115.00	100.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	94.00	85.00	77.00	70.00	65.00	63.00	61.00
Area	24.48	26.11	27.74				
Pressure	58.00	61.00	59.00				

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75
PRESSURE	582.00	29.00	19.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	582.00	303.00	211.00	164.00	137.00	118.00	115.00
LENGTH	10.67	12.00	13.33				
PRESSURE	101.00	91.00	88.00				

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 117 LONG TONS: TIME FRAME 39; REAL TIME 1.22
FRAME 41; ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

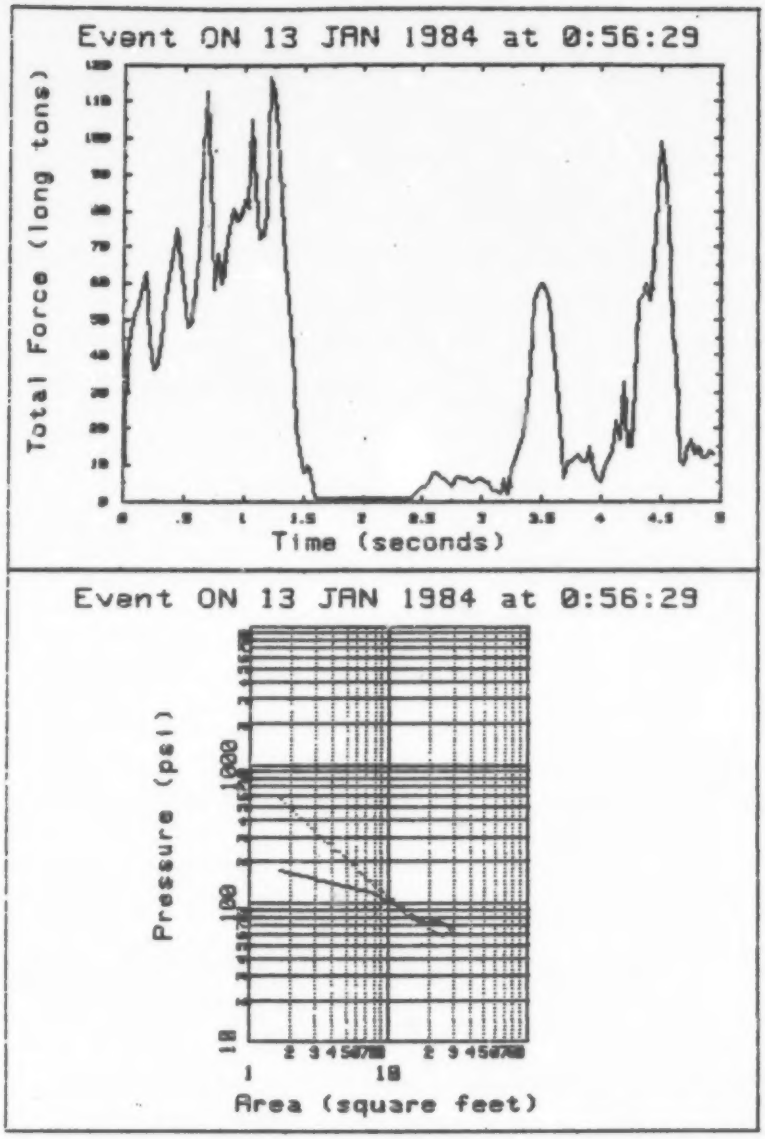
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	170.00	147.00	136.00	127.00	118.00	106.00	97.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	86.00	80.00	73.00	74.00	72.00	77.00	75.00
Area	24.48	26.11	27.74	29.38			
Pressure	72.00	69.00	65.00	62.00			

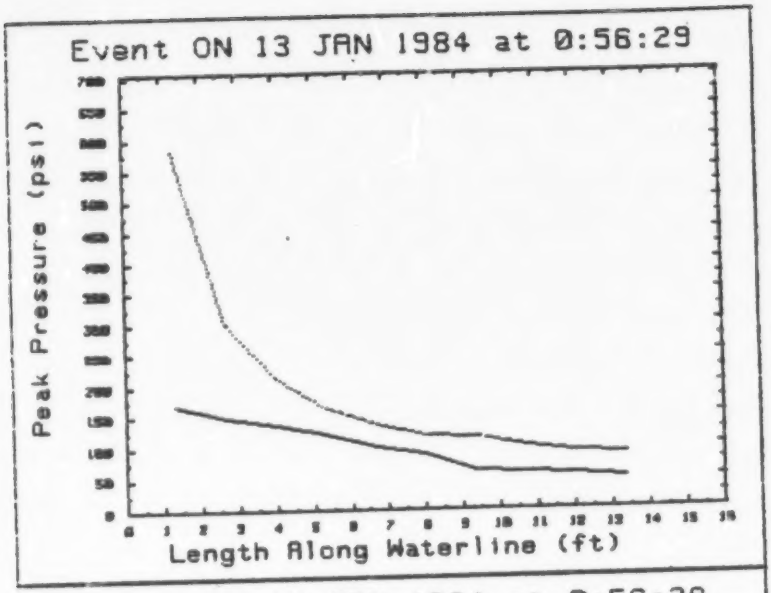
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

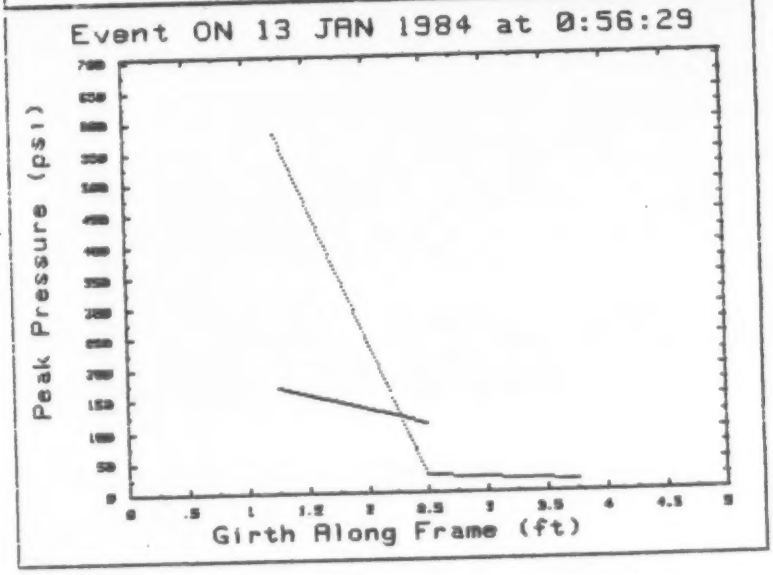
GIRTH	1.25	2.50
PRESSURE	170.00	112.00

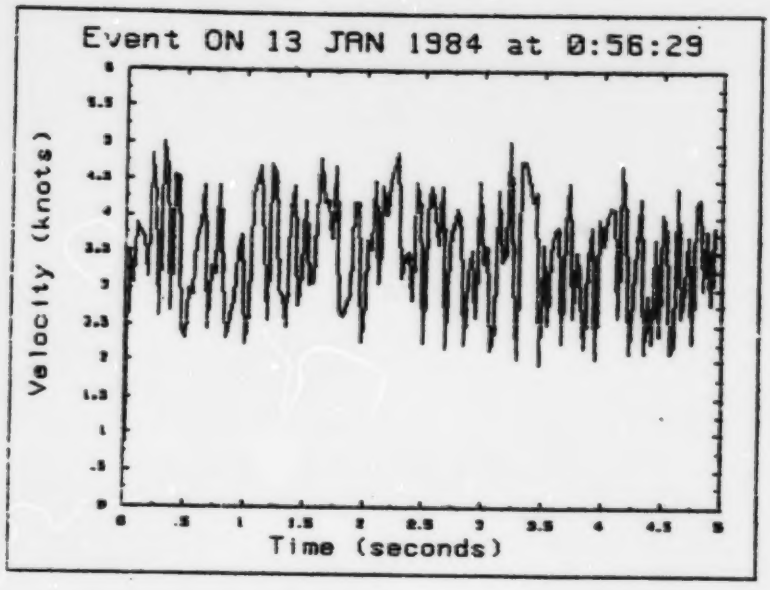
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	170.00	147.00	136.00	122.00	100.00	88.00	60.00
LENGTH	10.67	12.00	13.33				
PRESSURE	59.00	55.00	49.00				


Event ON 13 JAN 1984 at 0:56:29
Total Force (long tons)
Time (seconds)
Event ON 13 JAN 1984 at 0:56:29
Pressure (psi)
Area (square feet)

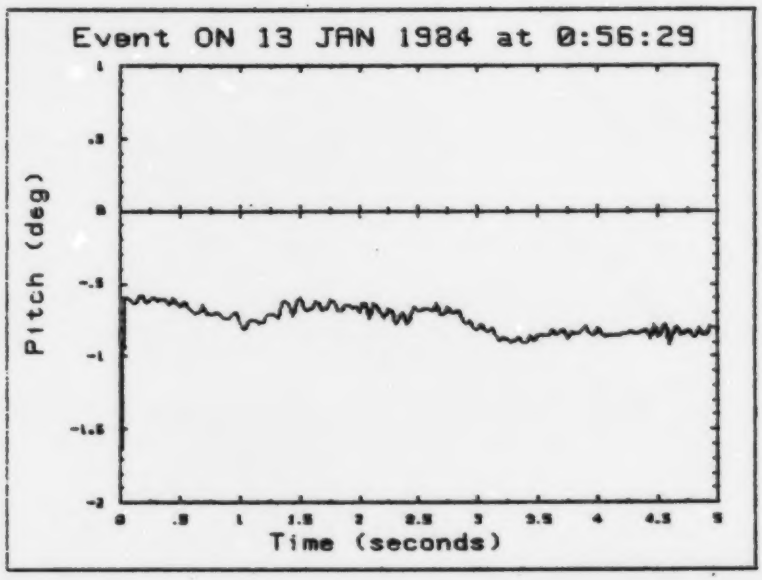

Event ON 13 JAN 1984 at 0:56:29
Peak Pressure (psi)
Length Along Waterline (ft)

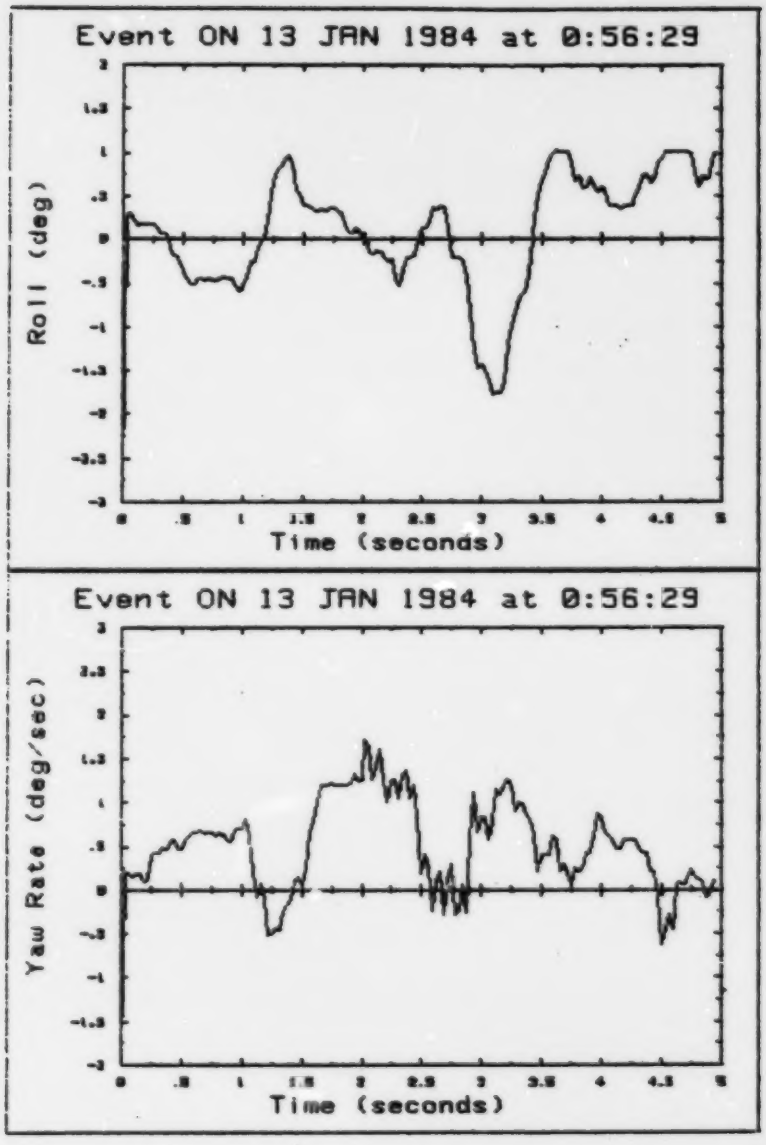

Event ON 13 JAN 1984 at 0:56:29
Peak Pressure (psi)
Girth Along Frame (ft)

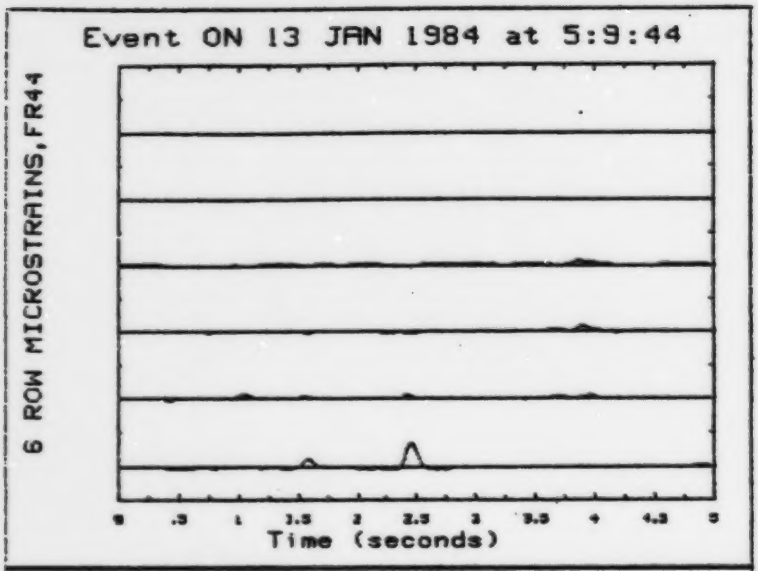

Event ON 13 JAN 1984 at 0:56:29
Velocity (knots)
Time (seconds)

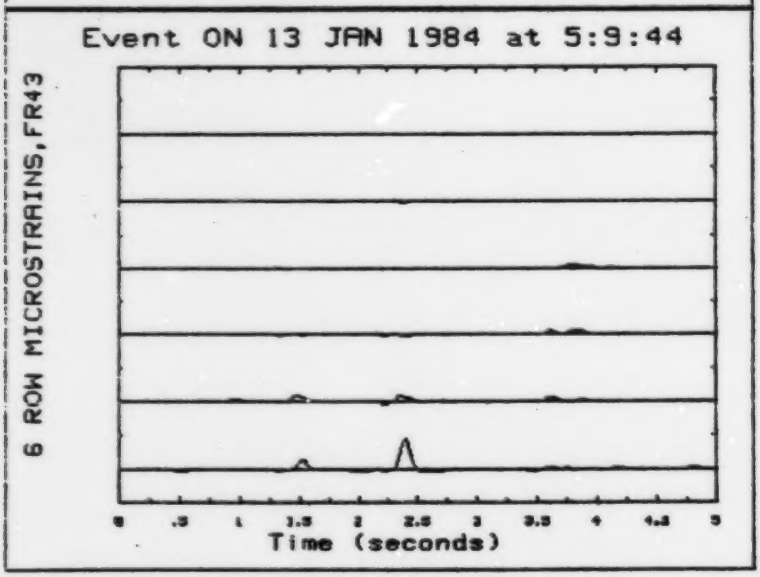
AVERAGE PITCH	.65 Deg Bow Down
AVERAGE ROLL	.28 Deg To Starboard
AVERAGE YAW RATE	.56 Deg/Sec Bow To Starboard

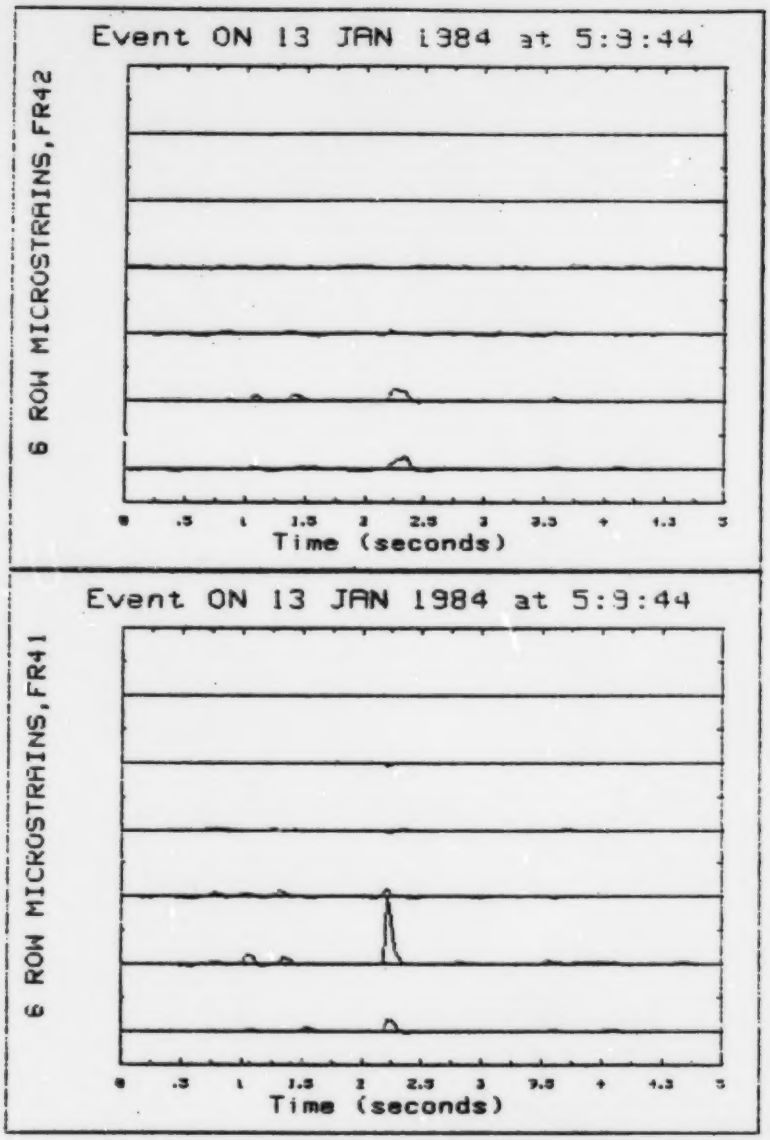
ZERO(1) = 1784	ZERO(2) = 2072
ZERO(3) = 3509	ZERO(4) = 3002

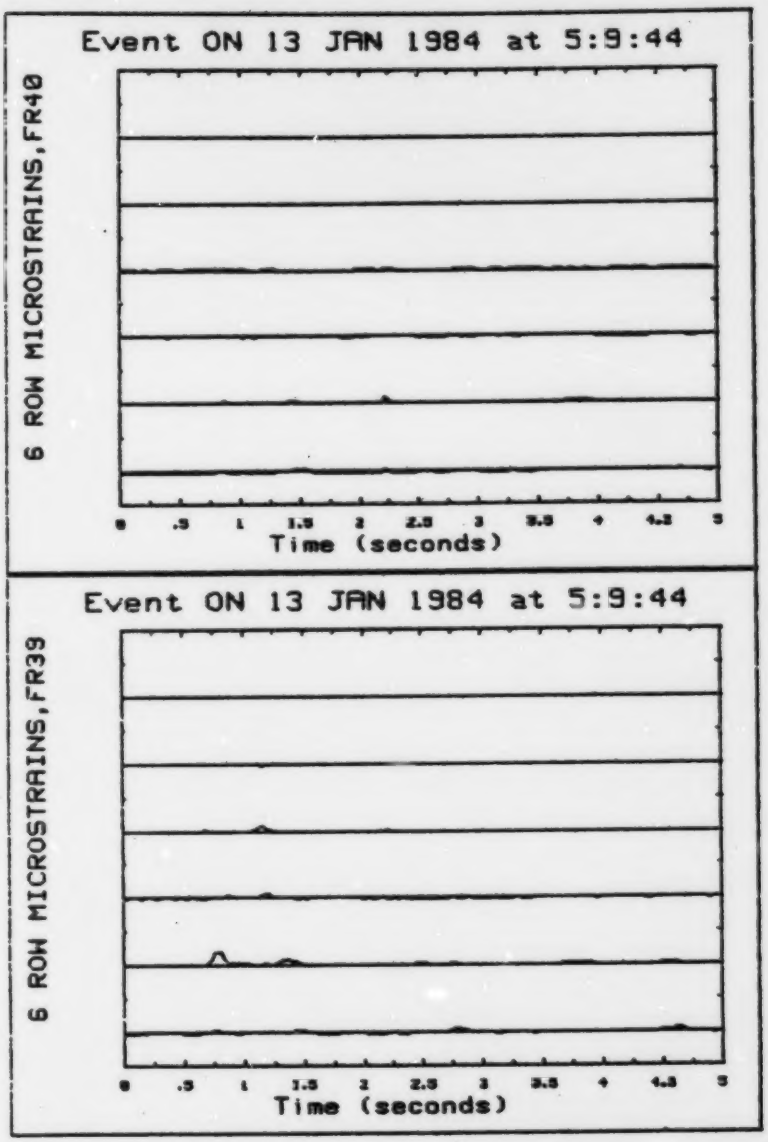


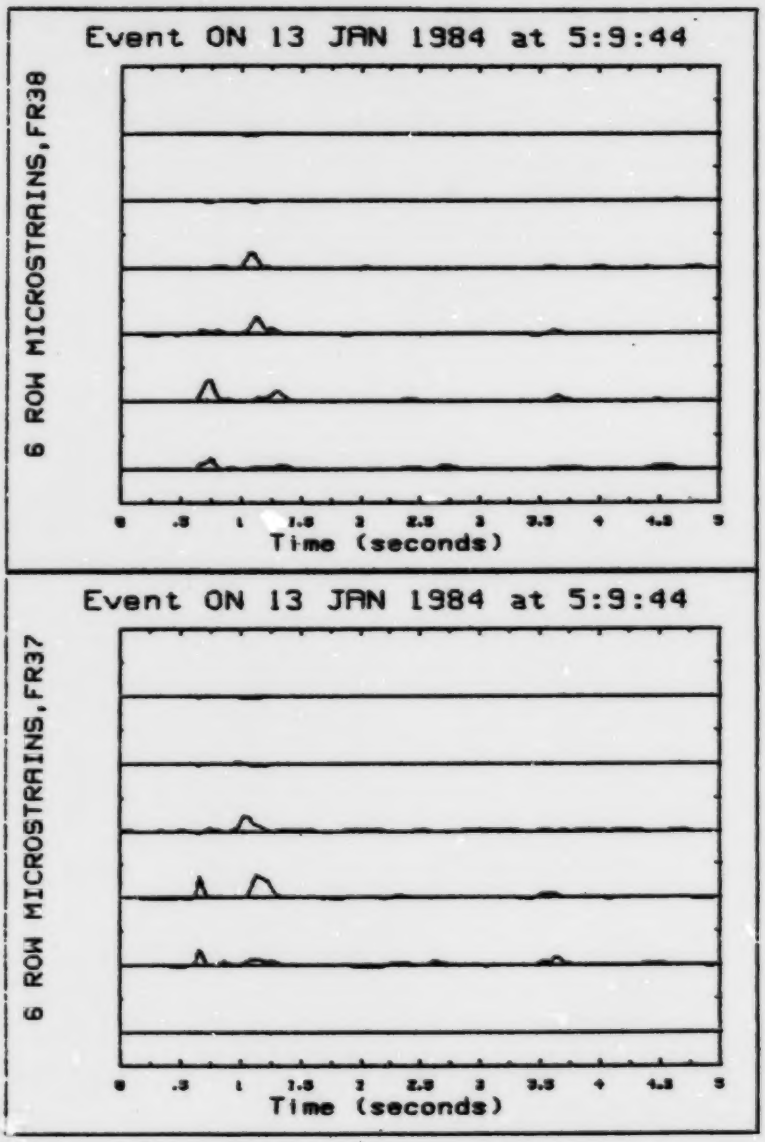

Event ON 13 JAN 1984 at 0:56:29
Roll (deg)
Time (seconds)
Event ON 13 JAN 1984 at 0:56:29
Yaw Rate (deg/sec)
Time (seconds)

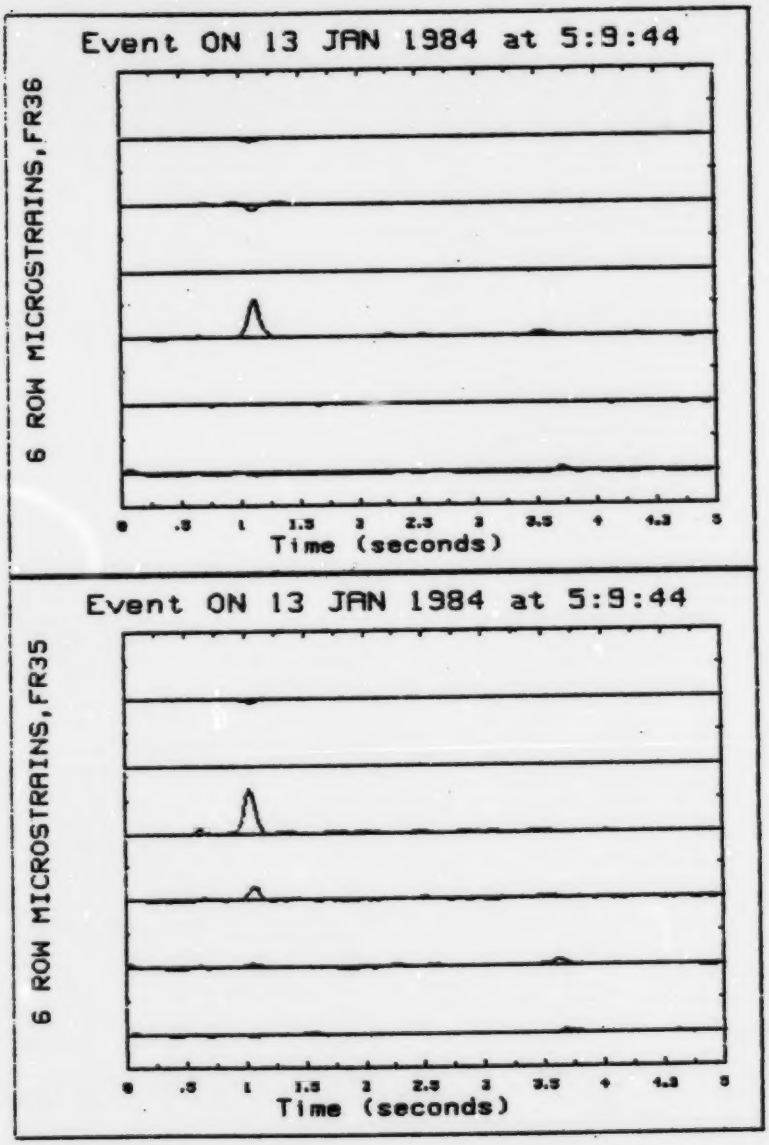

Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR44
Time (seconds)

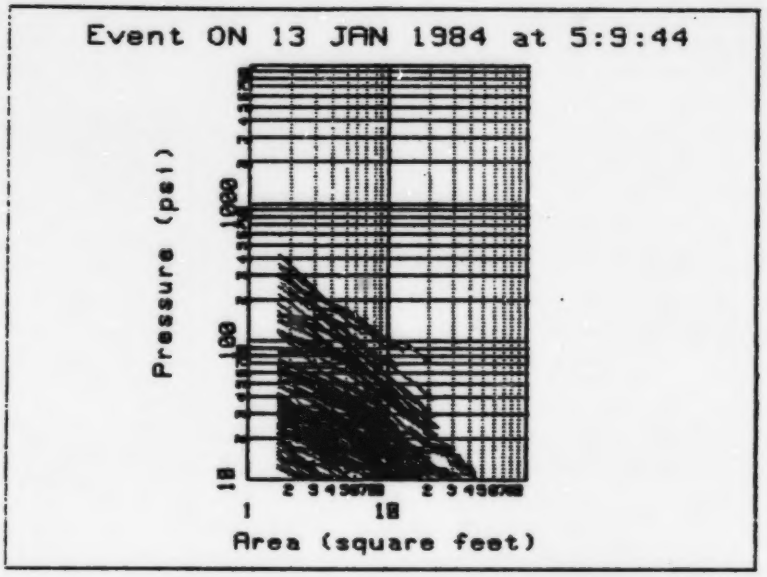

Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR43
Time (seconds)


Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR36
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 13 JAN 1984 at 5:9:44
6 ROW MICROSTRAINS,FR35
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)



EVENT ON 13 JAN 1984 AT 5:9:44
TAPE NUMBER 4 : TRACK NUMBER 3 : FILE NUMBER 57
PEAK STRAIN 272 : THRESHOLD 150
AVERAGE SHIP SPEED 8.78 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 580 PSI; TIME FRAME 71; REAL TIME 2.22
FRAME 41; ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area 1.63
Pressure 580.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH 1.25
PRESSURE 580.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH 1.33
PRESSURE 580.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 88 LONG TONS: TIME FRAME 35: REAL TIME 1.09
FRAME 36; ROW 6

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	278.00	163.00	129.00	127.00	114.00	101.00	91.00

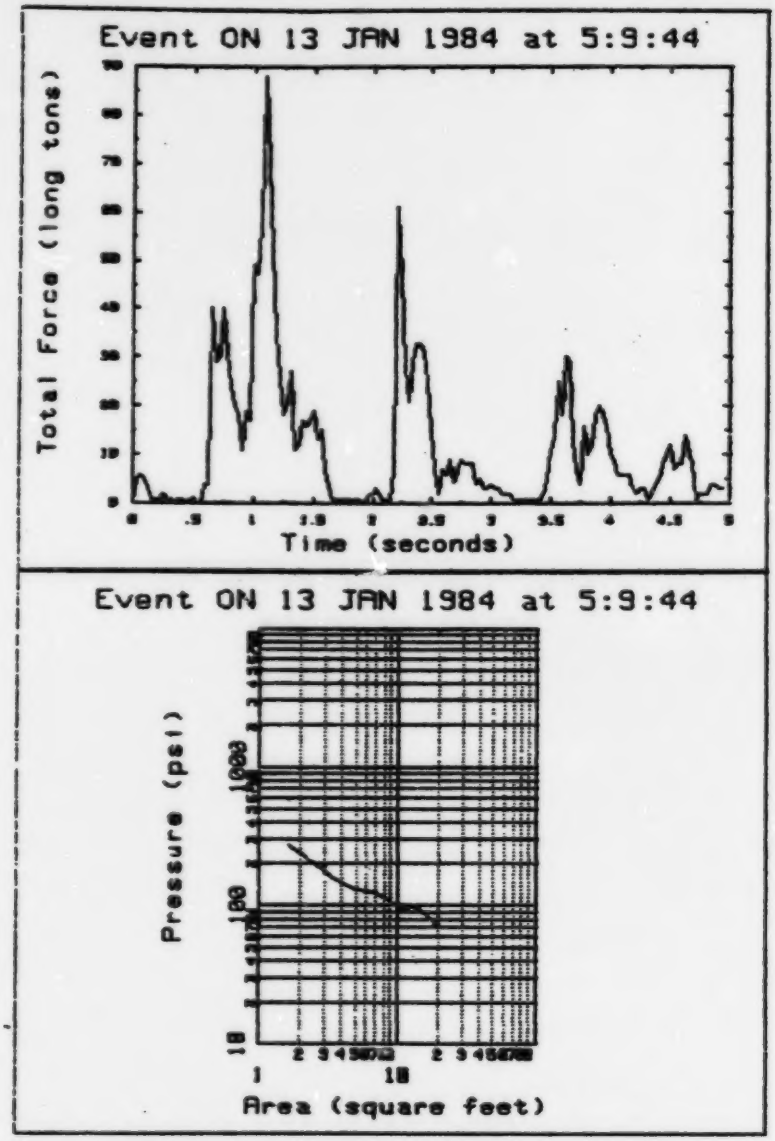
Area	13.06	14.69	16.32	17.95	19.58
Pressure	100.00	91.00	83.00	76.00	70.00

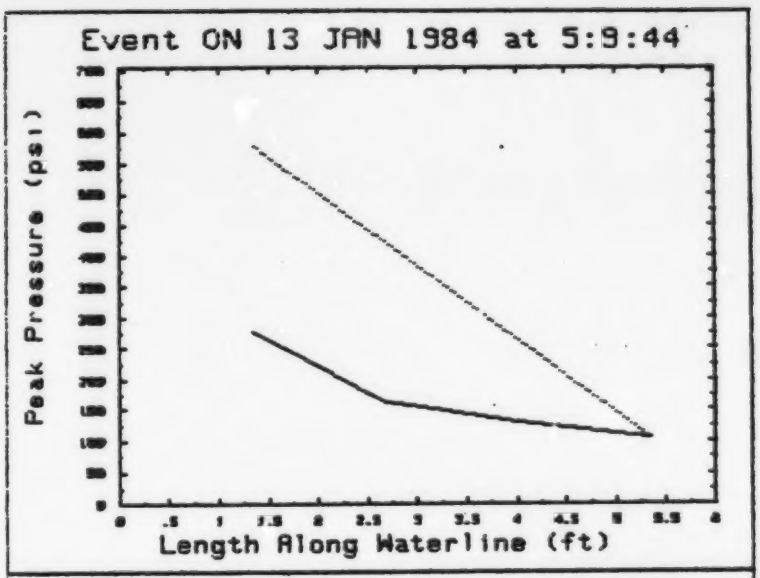
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

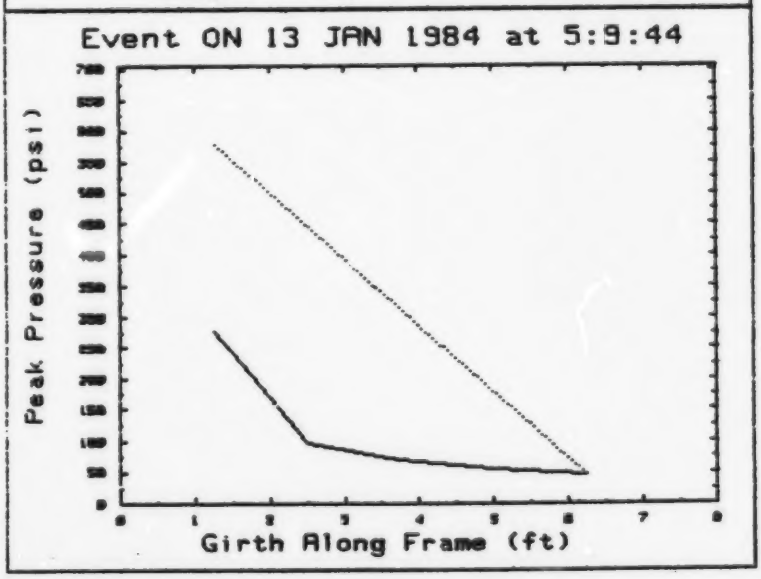
GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	278.00	97.00	70.00	56.00	46.00

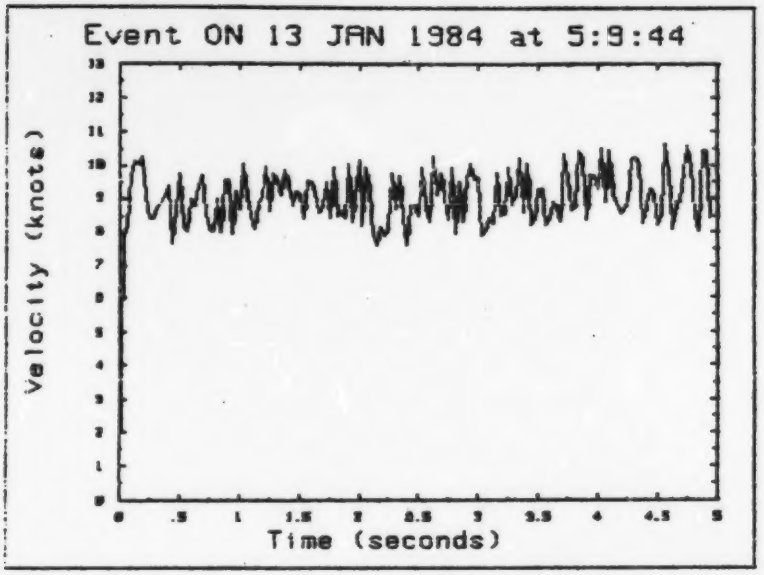
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33
PRESSURE	278.00	163.00	129.00	105.00


Event ON 13 JAN 1984 at 5:9:44
Total Force (long tons)
Time (seconds)
Event ON 13 JAN 1984 at 5:9:44
Pressure (psi)
Area (square feet)

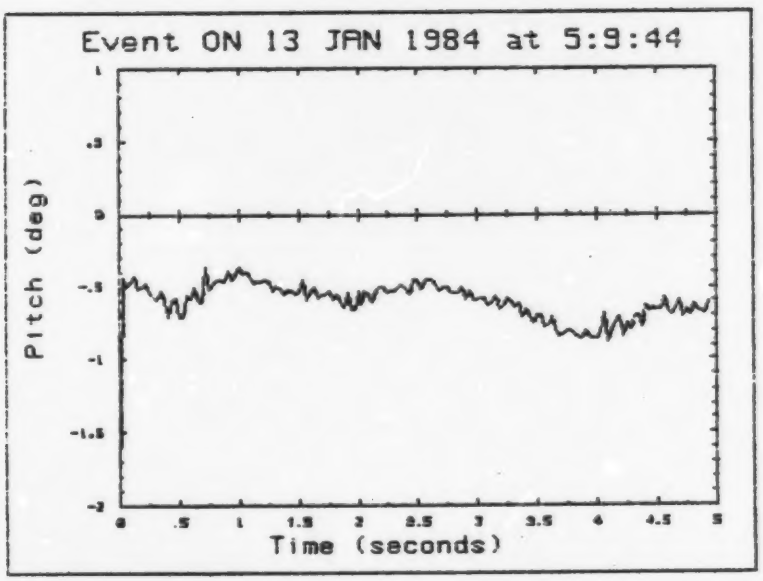

Event ON 13 JAN 1984 at 5:9:44
Peak Pressure (psi)
Length Along Waterline (ft)

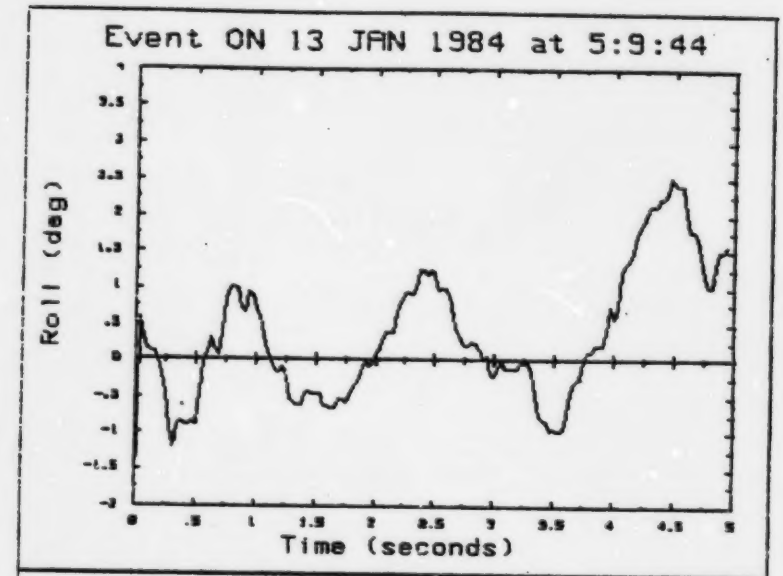

Event ON 13 JAN 1984 at 5:9:44
Peak Pressure (psi)
Girth Along Frame (ft)

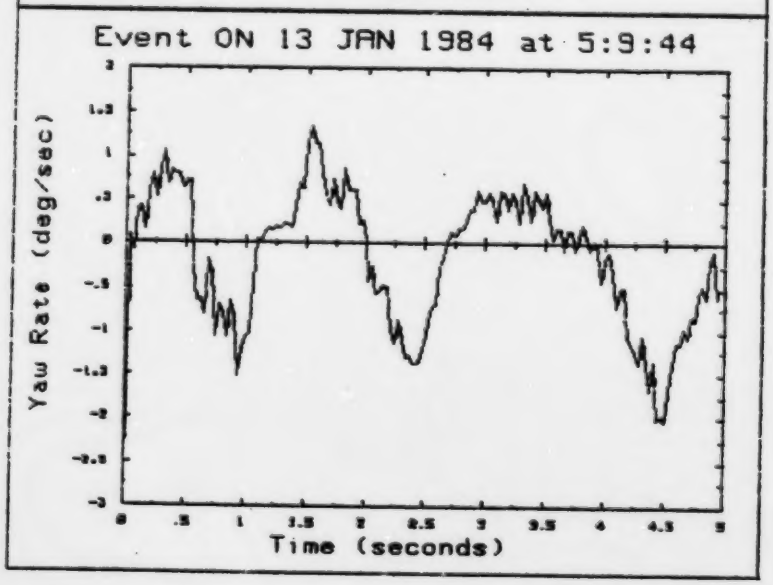

Event ON 13 JAN 1984 at 5:9:44
Velocity (knots)
Time (seconds)

AVERAGE PITCH	.58 Deg Bow Down
AVERAGE ROLL	.37 Deg To Starboard
AVERAGE YAW RATE	.19 Deg/Sec Bow To Starboard

ZERO(1) = 1784	ZERO(2) = 2072
ZERO(3) = 3509	ZERO(4) = 3002




Event ON 13 JAN 1984 at 5:9:44
Roll (deg)
Time (seconds)


Event ON 13 JAN 1984 at 5:9:44
Yaw Rate (deg/sec)
Time (seconds)

APPENDIX D

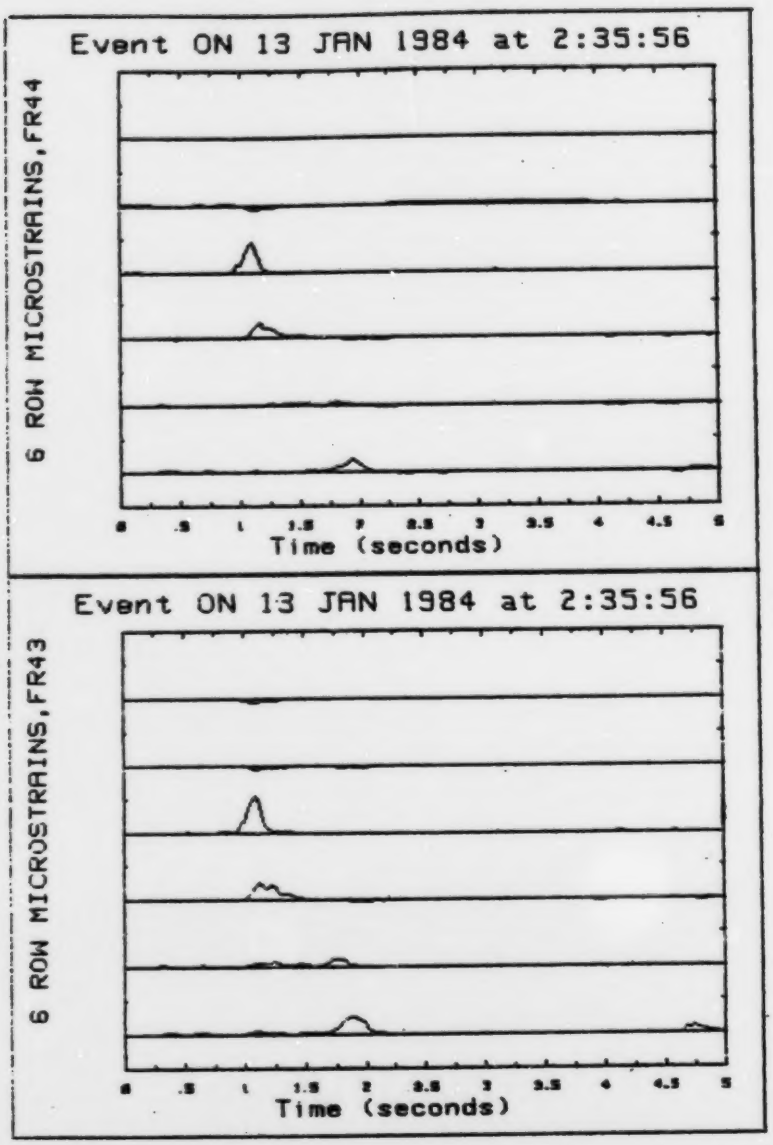
THE FIVE EVENTS OF HIGHEST PANEL FORCE

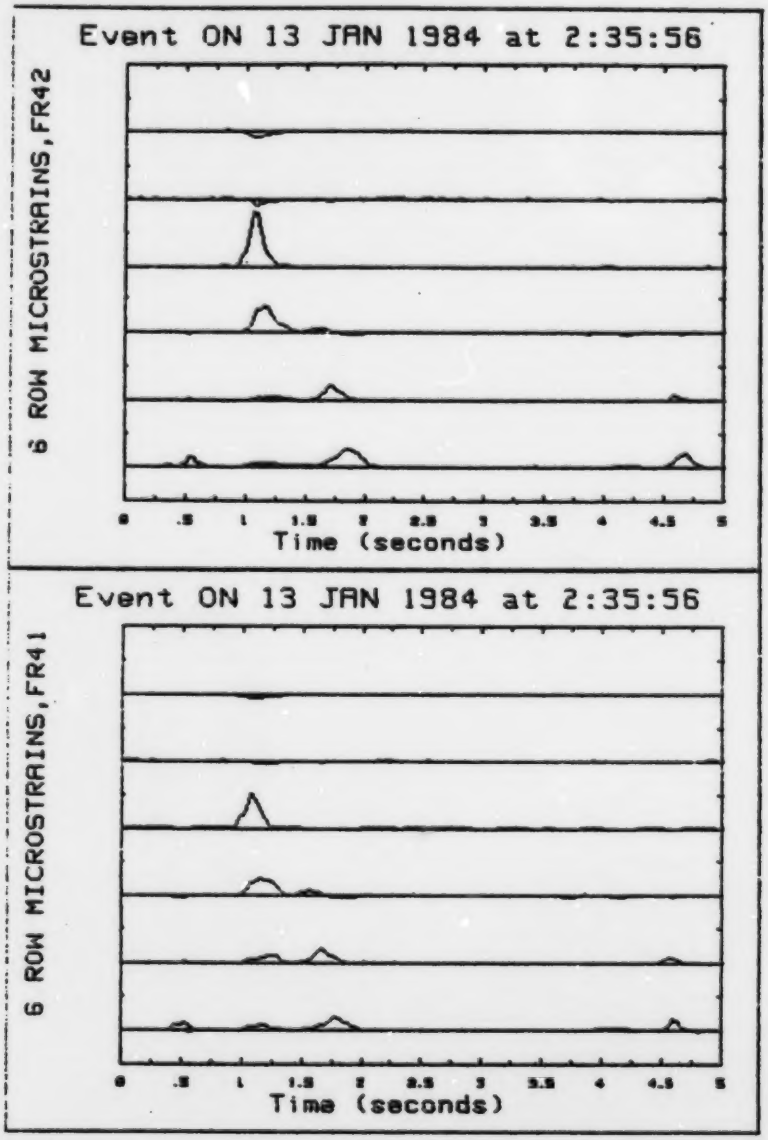
NOTE: Strain time-histories are normalized by the peak strain for the event

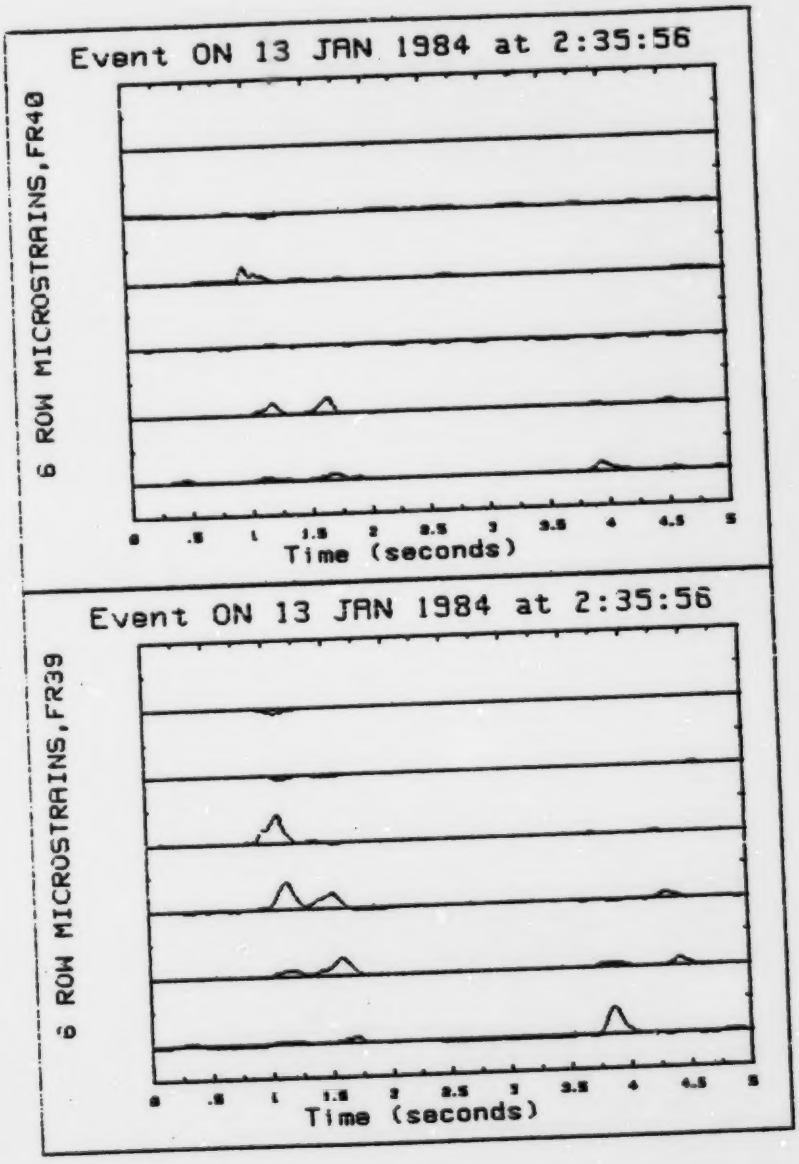
The characteristics of the five events which gave rise to the highest single panel peak pressure have been reproduced herein for the record and future use. This data is of course available for all events.

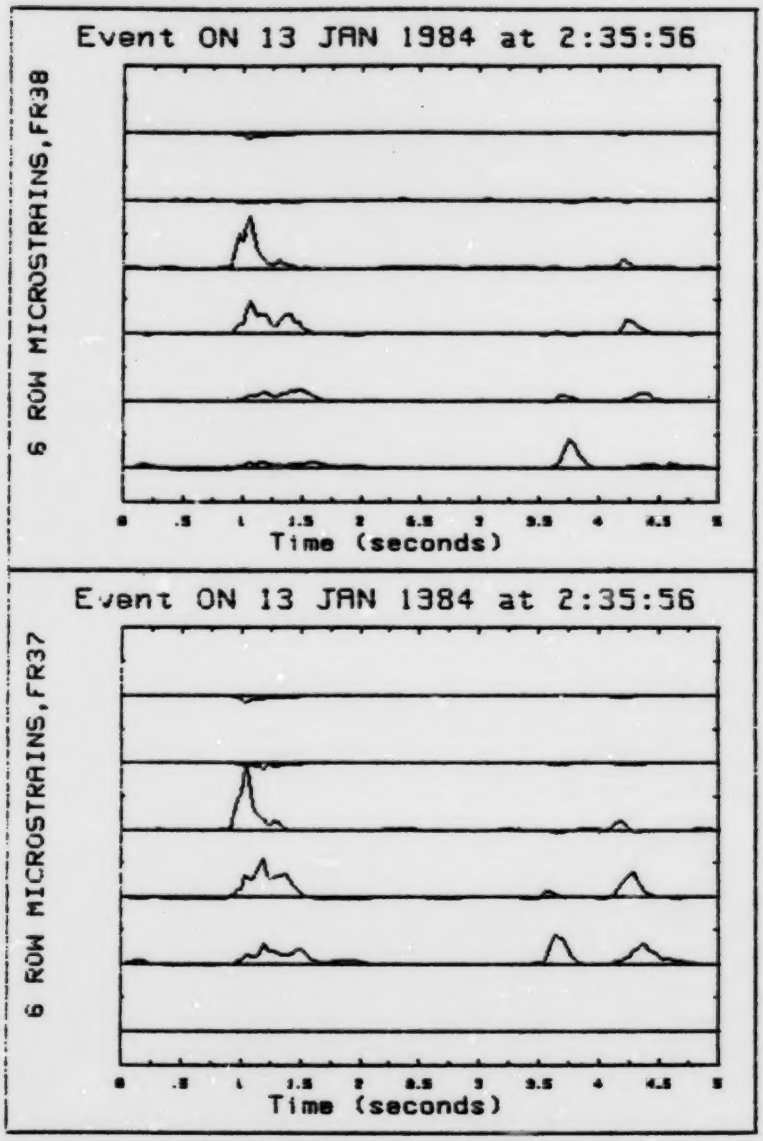
For each event, the time series of strains is presented, as six gauge channels (rows) on each of 10 charts (frames).

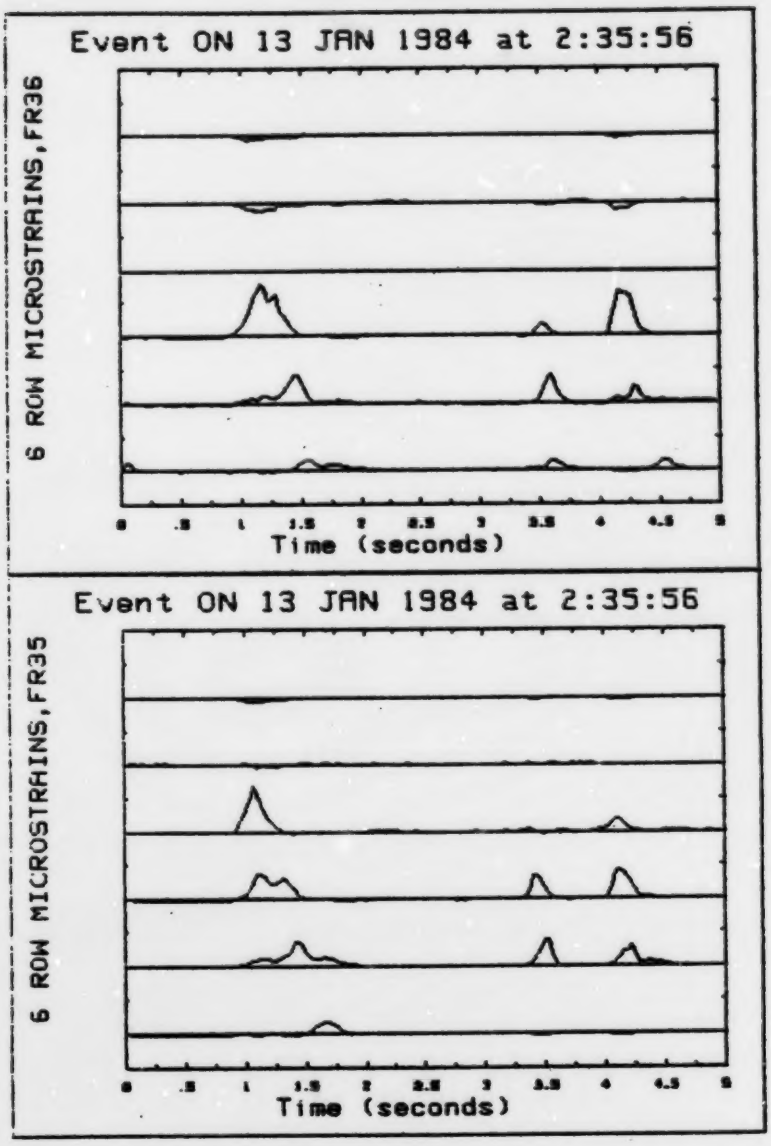
Pressure/area, pressure girth and length distribution data is presented, as well as force and ship motion time histories.

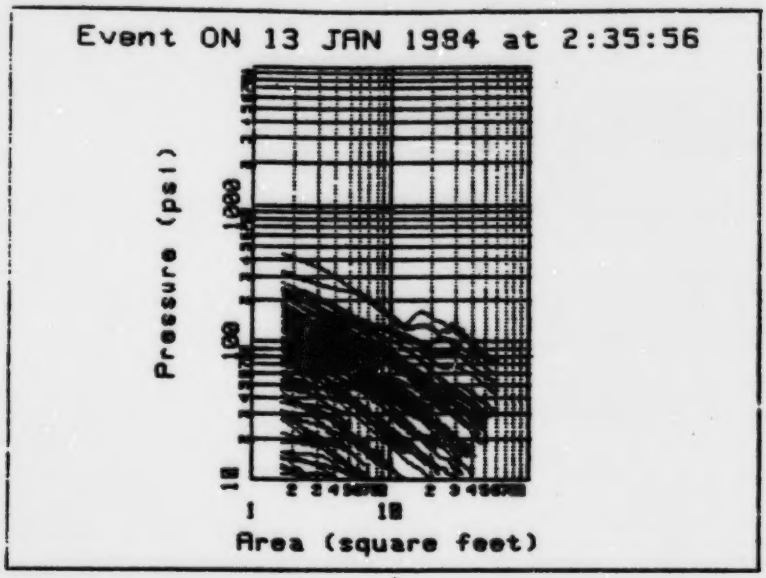

Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR44
Time (seconds)
Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR43
Time (seconds)


Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR40
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR39
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 13 JAN 1984 at 2:35:56
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 13 JAN 1984 AT 2:35:56
TAPE NUMBER 4 : TRACK NUMBER 3 : FILE NUMBER 36
PEAK STRAIN 196 : THRESHOLD 150
AVERAGE SHIP SPEED 6.66 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 440 PSI; TIME FRAME 33; REAL TIME 1.03
FRAME 37; ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	440.00	341.00	256.00	211.00	173.00	160.00	143.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	128.00	125.00	133.00	133.00	130.00	120.00	112.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	106.00	100.00	94.00	89.00	85.00	81.00	77.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	74.00	71.00	68.00	66.00	63.00	61.00	60.00
Area	47.33	48.96					
Pressure	58.00	56.00					

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	440.00	231.00	168.00	32.00	27.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	440.00	341.00	256.00	196.00	178.00	192.00	176.00

LENGTH 10.67
PRESSURE 165.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 268 LONG TONS; TIME FRAME 34; REAL TIME 1.06
FRAME 42: ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

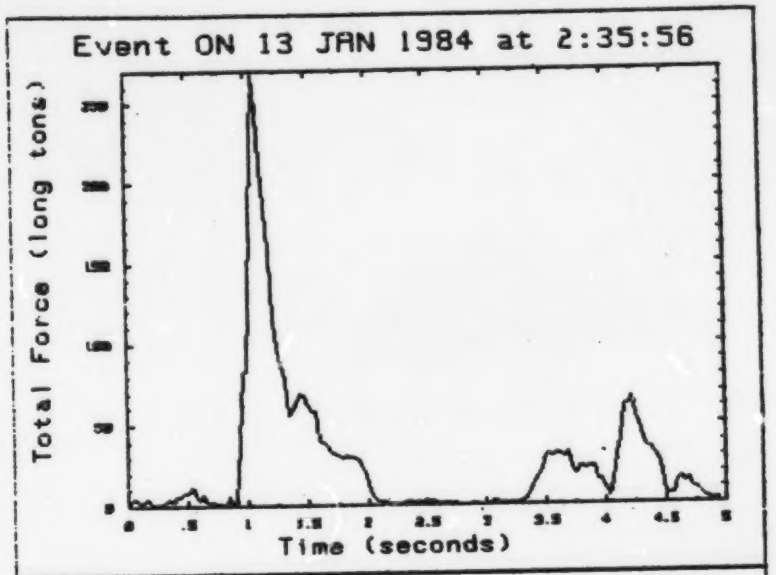
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	334.00	262.00	234.00	214.00	179.00	152.00	132.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	133.00	150.00	167.00	162.00	151.00	141.00	141.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	135.00	128.00	139.00	133.00	127.00	121.00	115.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	111.00	106.00	103.00	99.00	96.00	92.00	89.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	
Pressure	87.00	84.00	82.00	80.00	77.00	75.00	

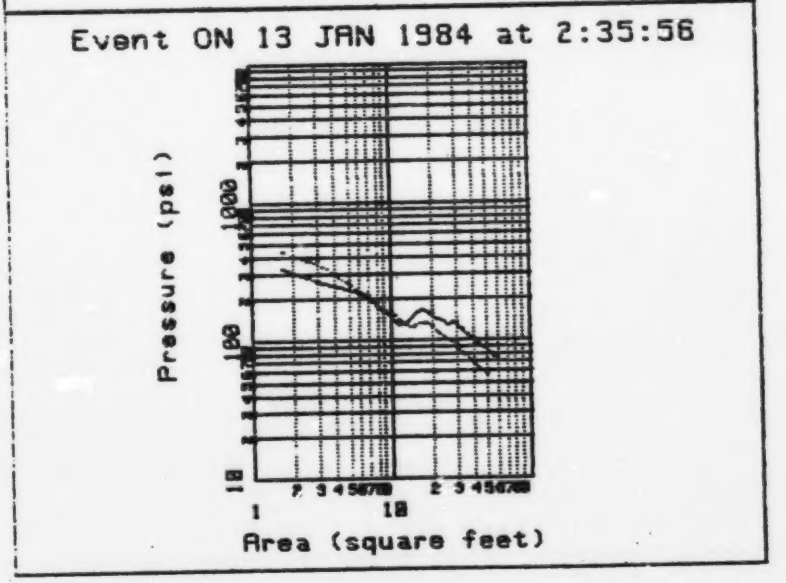
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

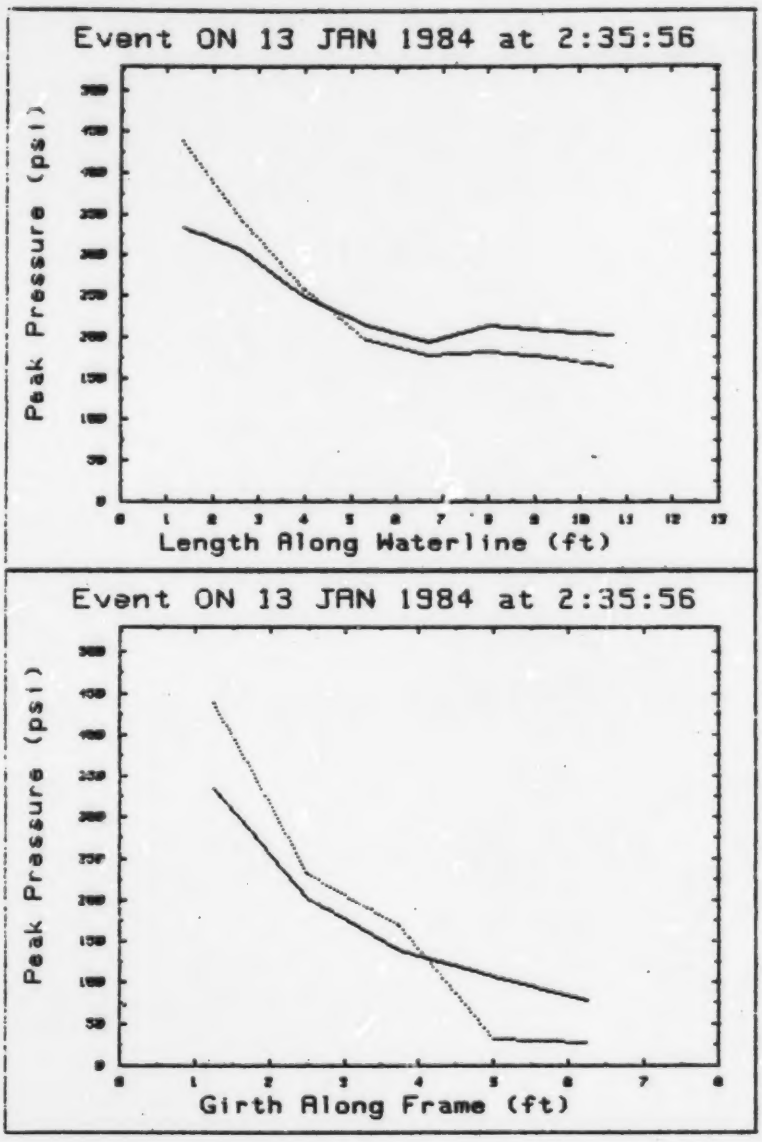
GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	334.00	203.00	140.00	106.00	78.00

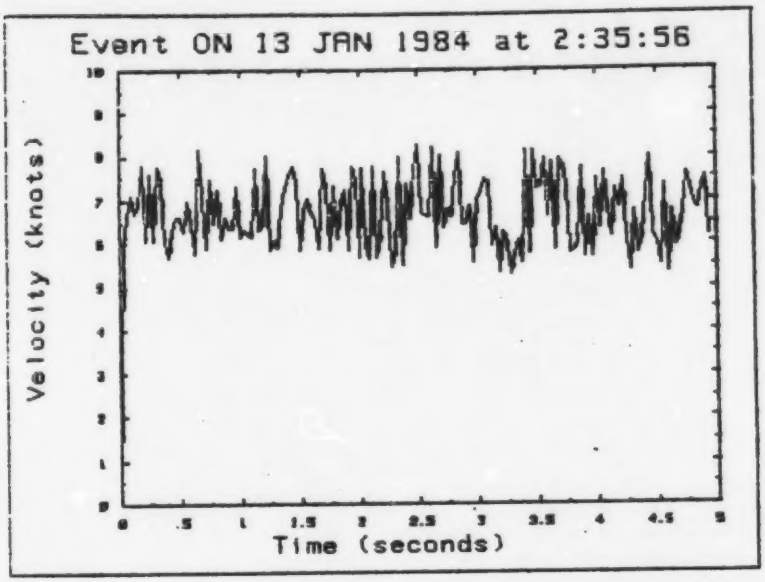
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	334.00	304.00	249.00	214.00	193.00	214.00	208.00
LENGTH	10.67						
PRESSURE	202.00						


Event ON 13 JAN 1984 at 2:35:56
Total Force (long tons)
Time (seconds)

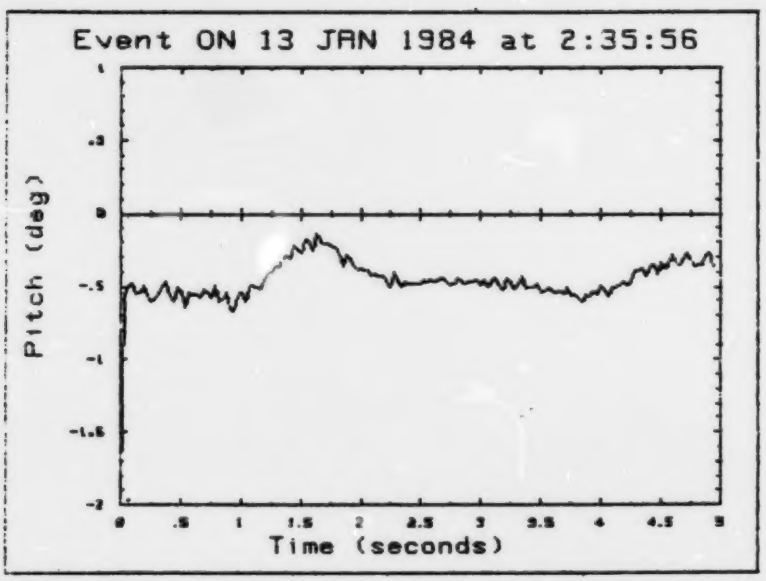

Event ON 13 JAN 1984 at 2:35:56
Pressure (psi)
Area (square feet)

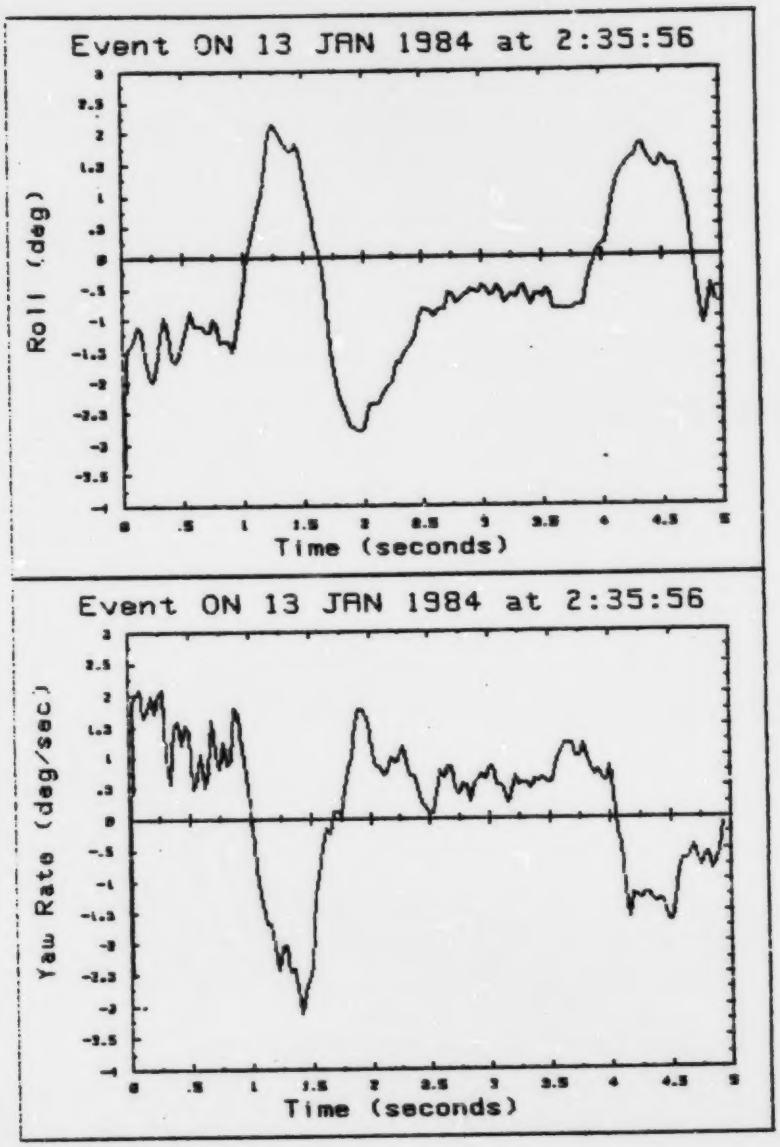

Event ON 13 JAN 1984 at 2:35:56
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 13 JAN 1984 at 2:35:56
Peak Pressure (psi)
Girth Along Frame (ft)

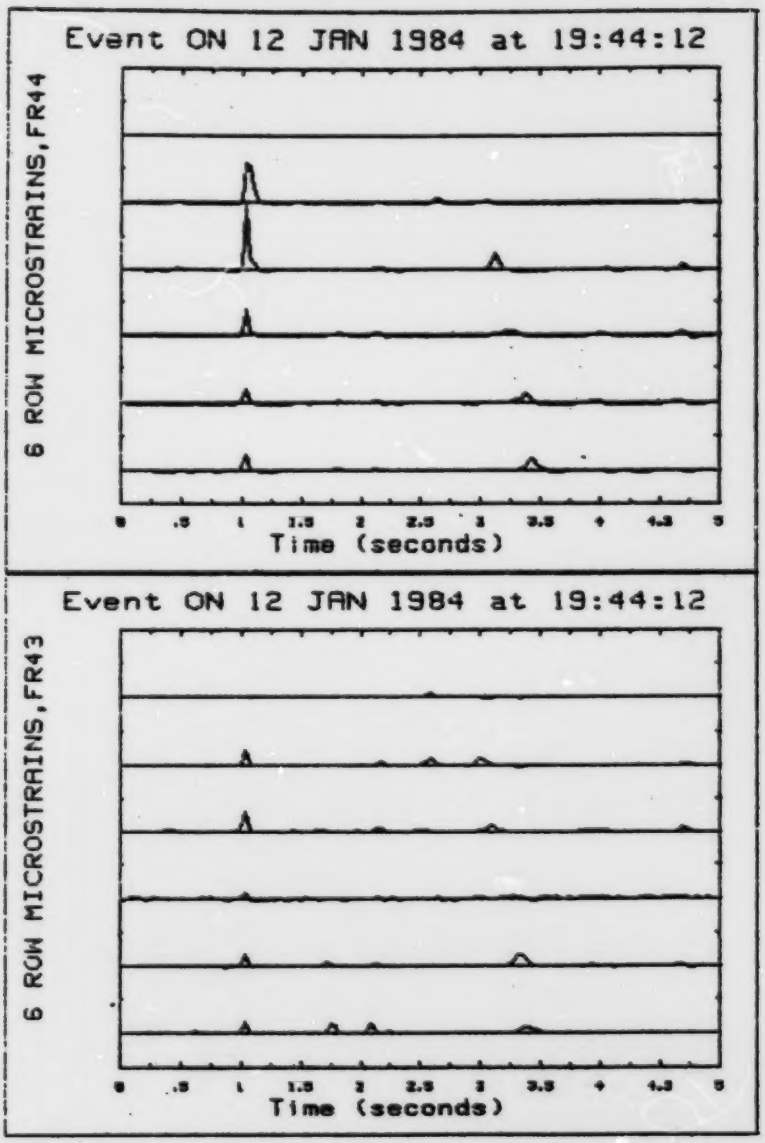

Event ON 13 JAN 1984 at 2:35:56
Velocity (knots)
Time (seconds)

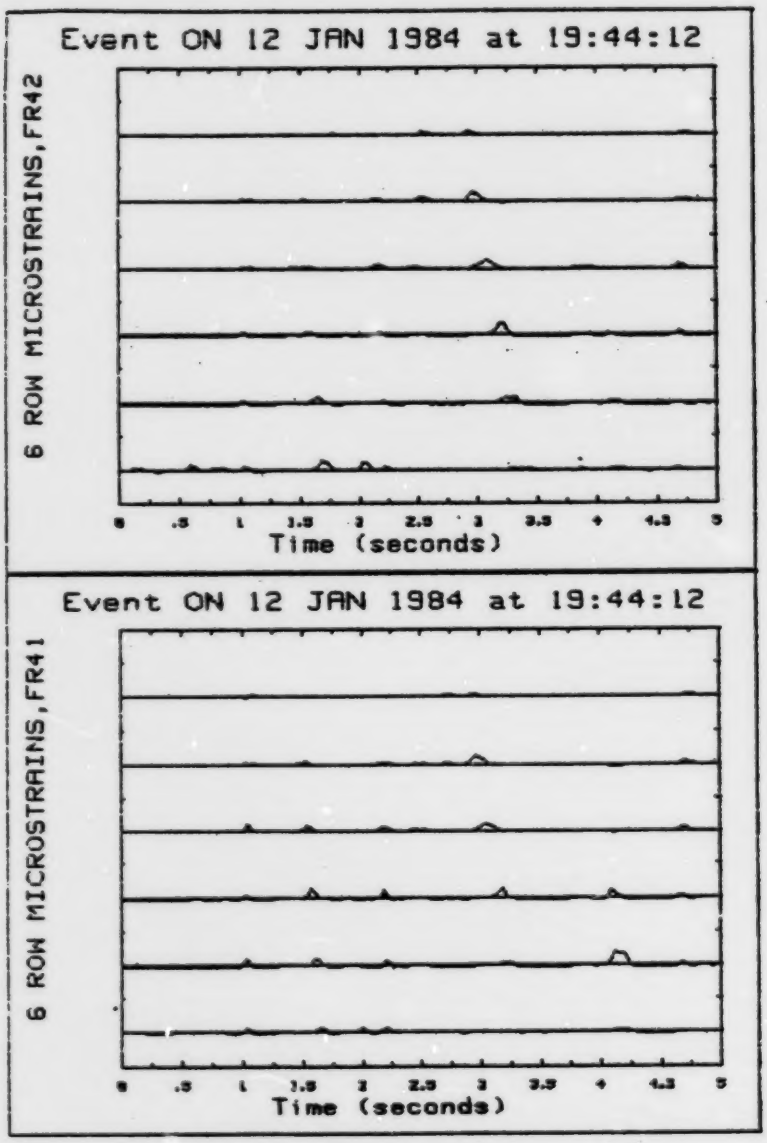
AVERAGE PITCH	.55	Deg Bow Down
AVERAGE ROLL	1.25	Deg To Starboard
AVERAGE YAW RATE	1.11	Deg/Sec Bow To Starboard

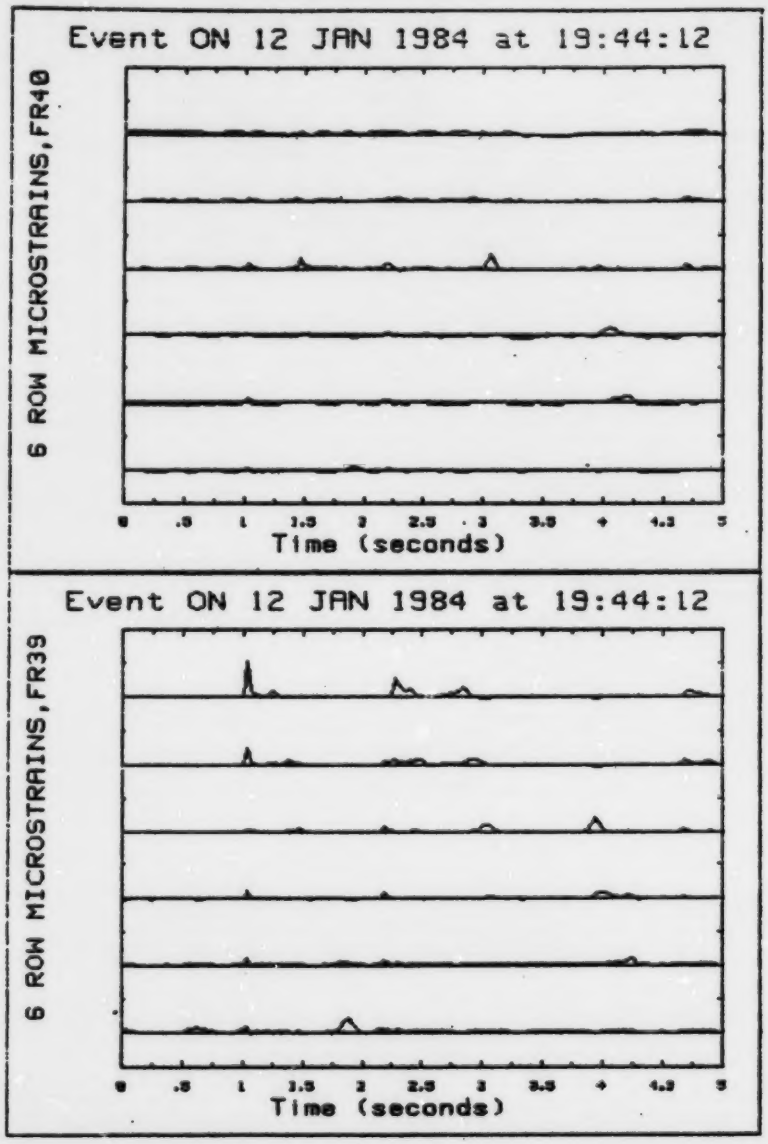
ZERO(1) =	1784	ZERO(2) =	2072
ZERO(3) =	3509	ZERO(4) =	3002

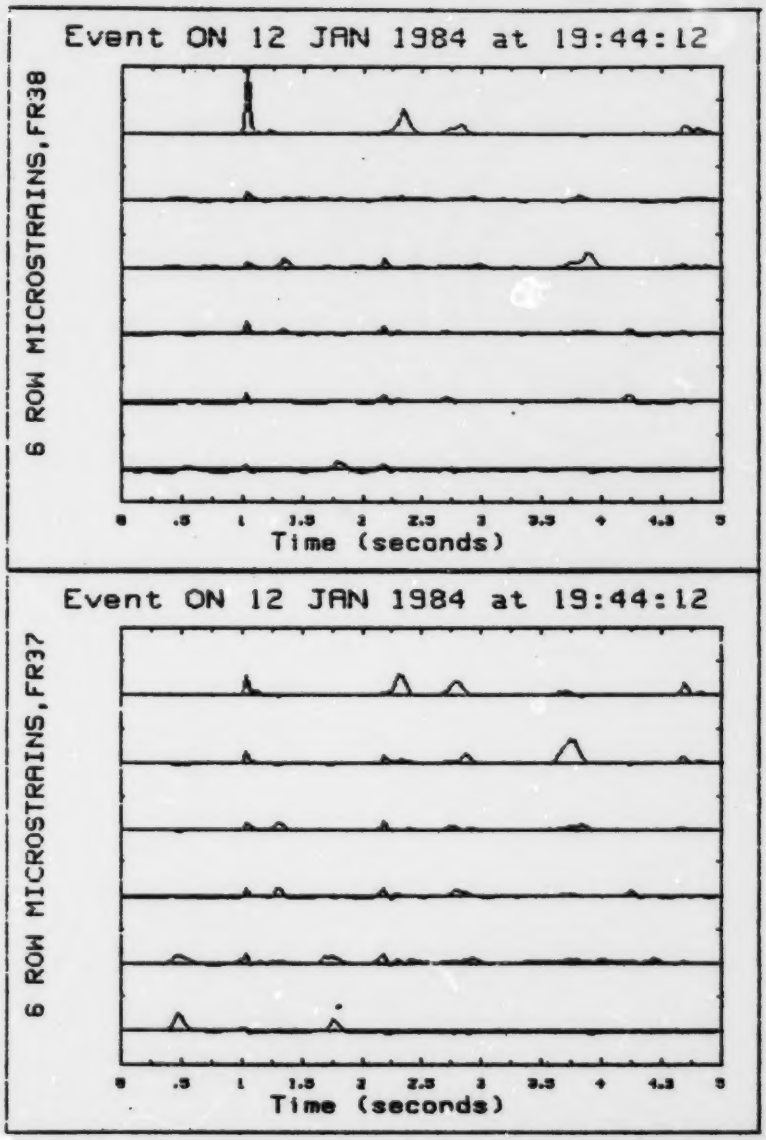


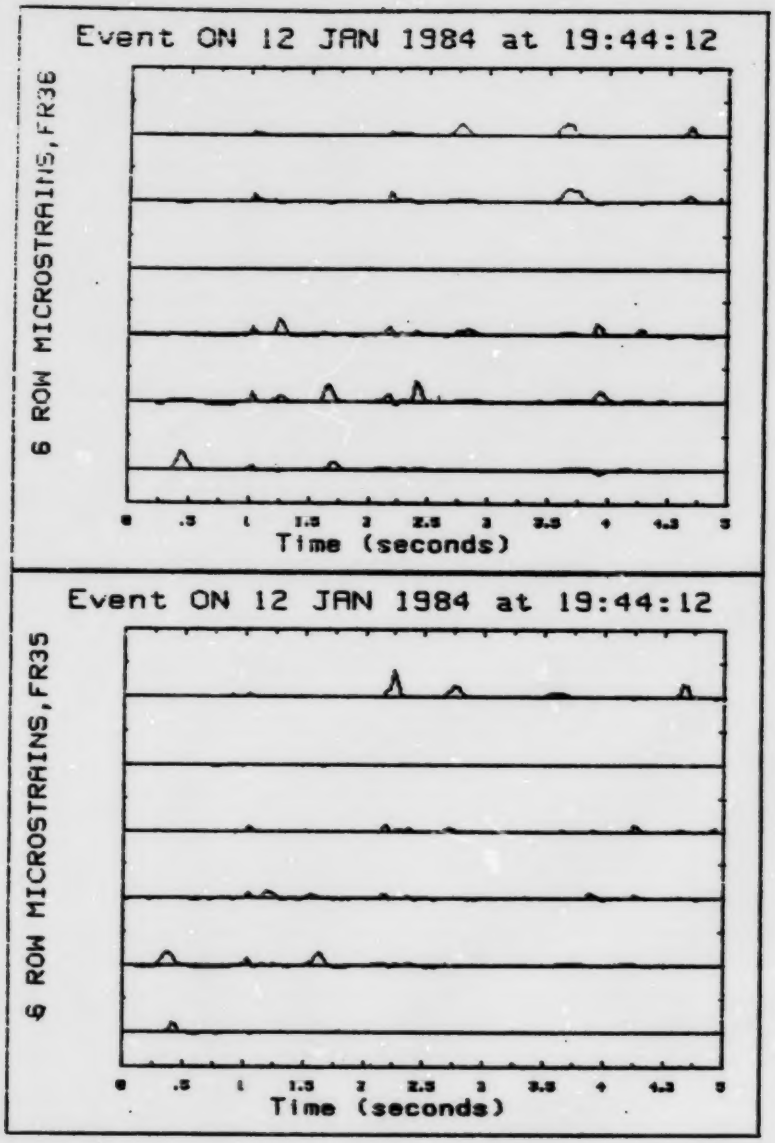

Event ON 13 JAN 1984 at 2:35:56
Roll (deg)
Time (seconds)
Event ON 13 JAN 1984 at 2:35:56
Yaw Rate (deg/sec)
Time (seconds)

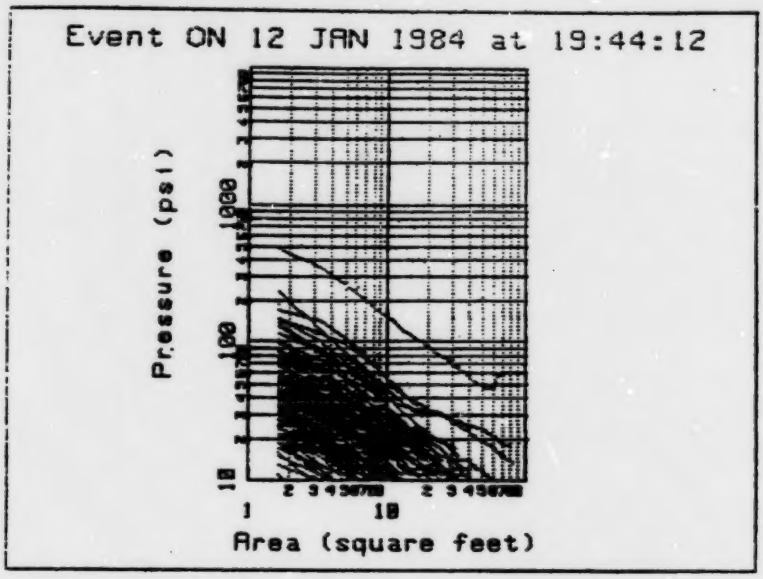

Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR44
Time (seconds)
Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR43
Time (seconds)


Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS, FR36
Time (seconds)
Event ON 12 JAN 1984 at 19:44:12
6 ROW MICROSTRAINS, FR35
Time (seconds)



EVENT ON 12 JAN 1984 AT 19:44:12
TAPE NUMBER 4 ; TRACK NUMBER 2 ; FILE NUMBER 14
PEAK STRAIN 162 ; THRESHOLD 150
AVERAGE SHIP SPEED 9.78 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 484 PSI: TIME FRAME 33; REAL TIME 1.03
FRAME 38; ROW 3

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	484.00	354.00	267.00	212.00	178.00	155.00	137.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	122.00	113.00	106.00	99.00	93.00	88.00	84.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	80.00	76.00	73.00	70.00	67.00	65.00	62.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	61.00	58.00	57.00	55.00	53.00	52.00	51.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	50.00	49.00	47.00	46.00	46.00	46.00	46.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	45.00	46.00	52.00	57.00	58.00	58.00	58.00
Area	70.17						
Pressure	57.00						

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	484.00	266.00	200.00	166.00	137.00	124.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	484.00	354.00	267.00	203.00	168.00	25.00	24.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 257 LONG TONS; TIME FRAME 33; REAL TIME 1.03
FRAME 38; ROW 3

AVERAGE PRESSURE (psi) vs AREA (square feet)

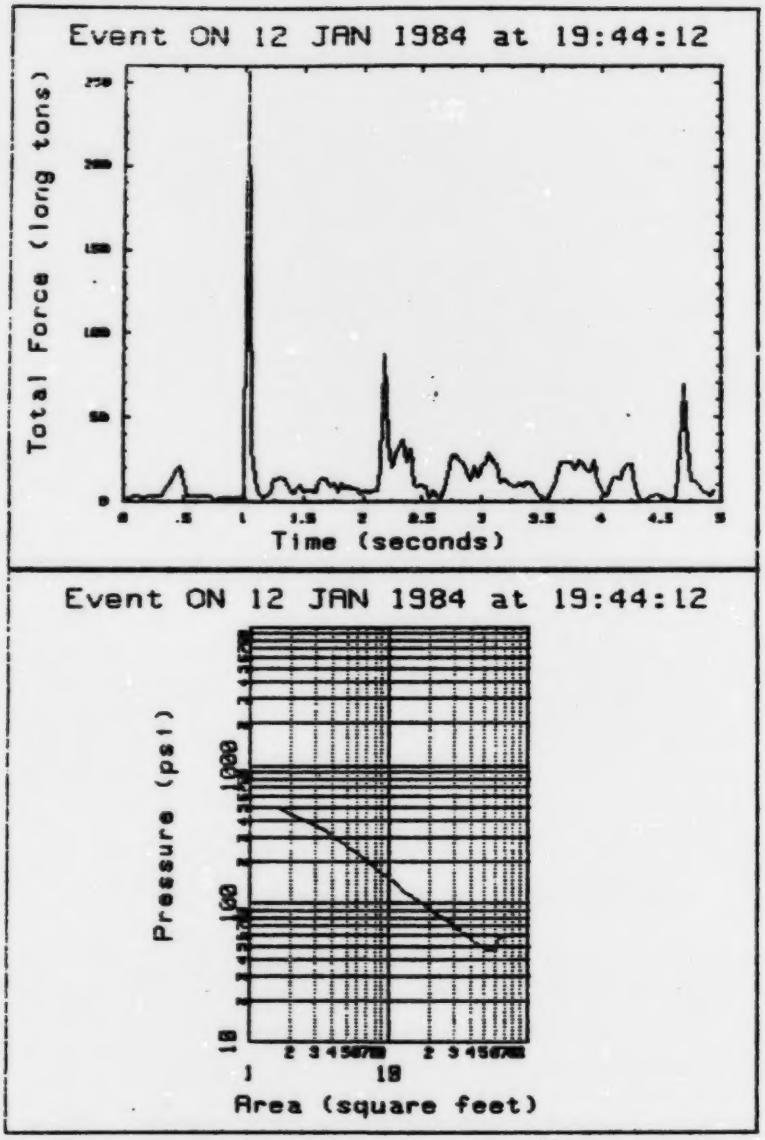
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	484.00	354.00	267.00	212.00	178.00	155.00	137.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	122.00	113.00	106.00	99.00	93.00	88.00	84.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	80.00	76.00	73.00	70.00	67.00	65.00	62.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	61.00	58.00	57.00	55.00	53.00	52.00	51.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	50.00	49.00	47.00	46.00	46.00	46.00	46.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	45.00	46.00	52.00	57.00	58.00	58.00	58.00
Area	70.17						
Pressure	57.00						

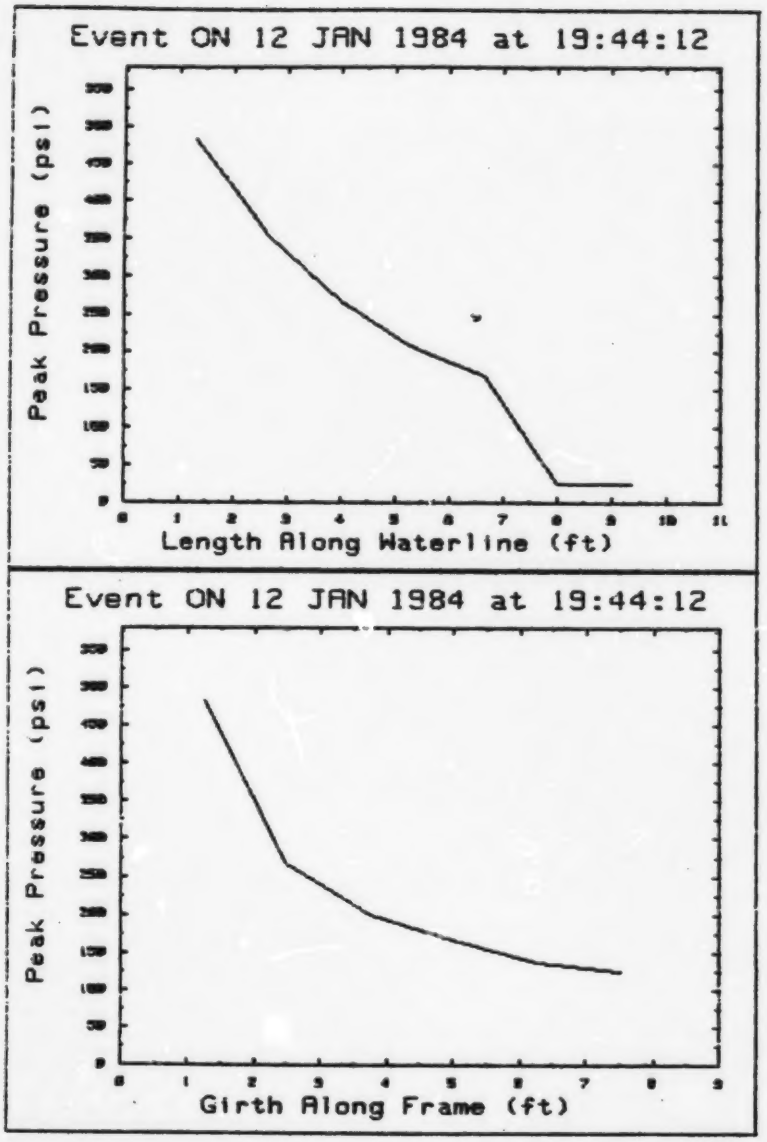
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

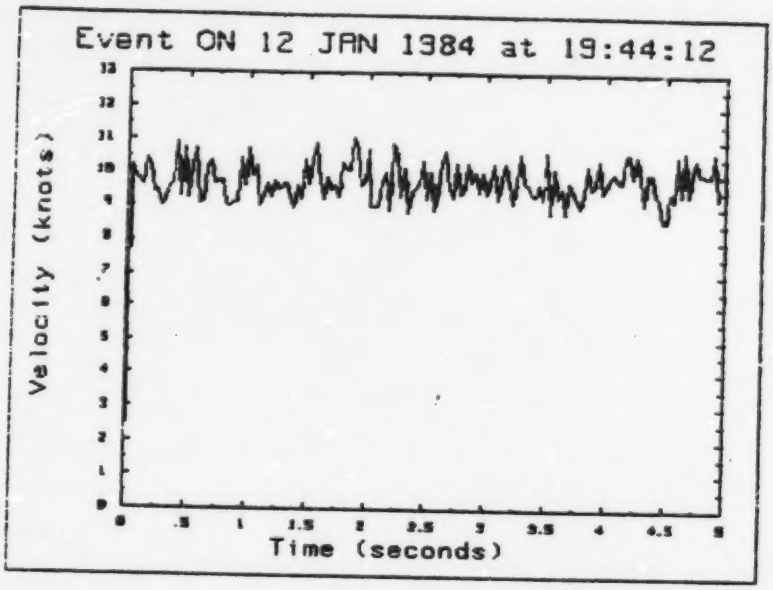
GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	484.00	266.00	200.00	166.00	137.00	124.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	484.00	354.00	267.00	203.00	168.00	25.00	24.00

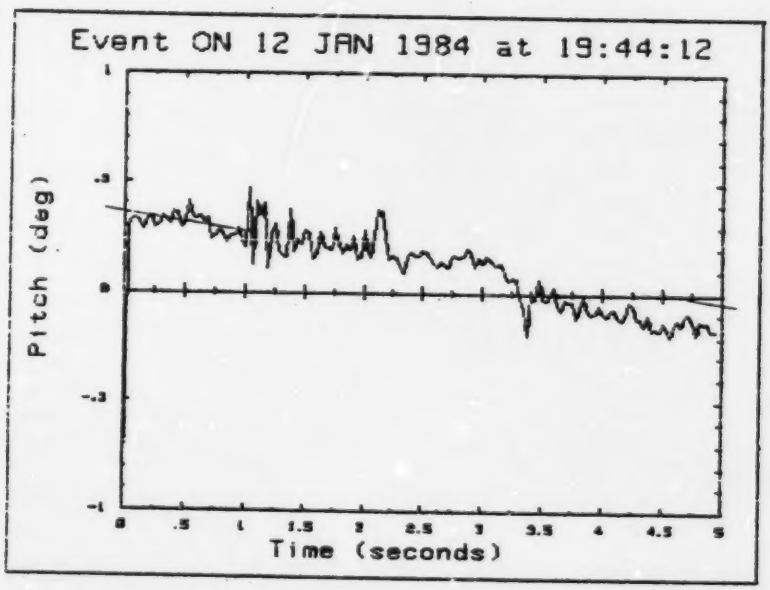

Event ON 12 JAN 1984 at 19:44:12
Total Force (long tons)
Time (seconds)
Event ON 12 JAN 1984 at 19:44:12
Pressure (psi)
Area (square feet)

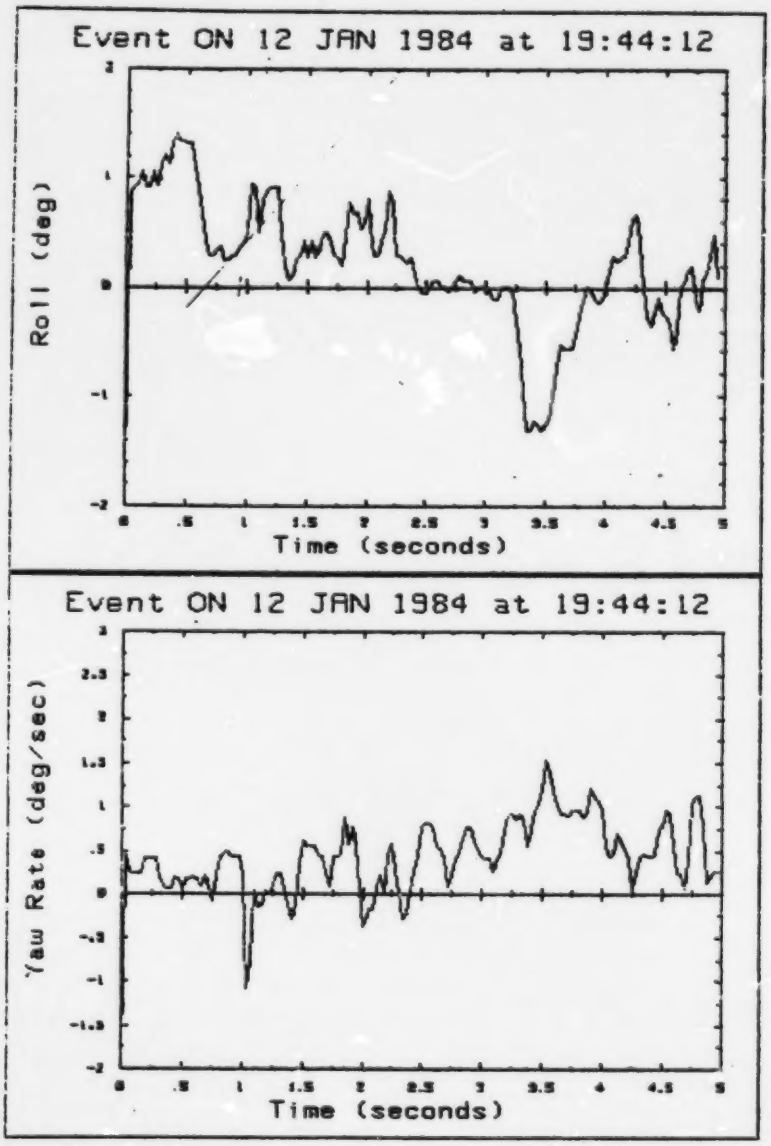

Event ON 12 JAN 1984 at 19:44:12
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 12 JAN 1984 at 19:44:12
Peak Pressure (psi)
Girth Along Frame (ft)

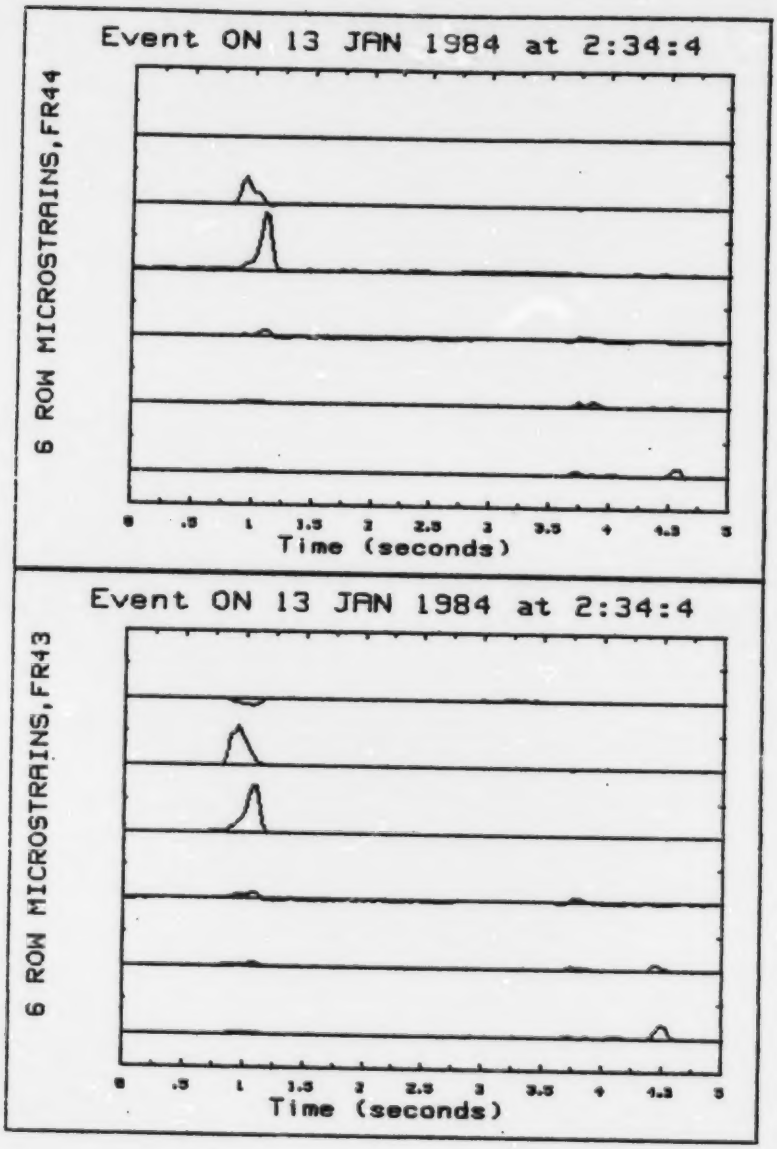

Event ON 12 JAN 1984 at 19:44:12
Velocity (knots)
Time (seconds)

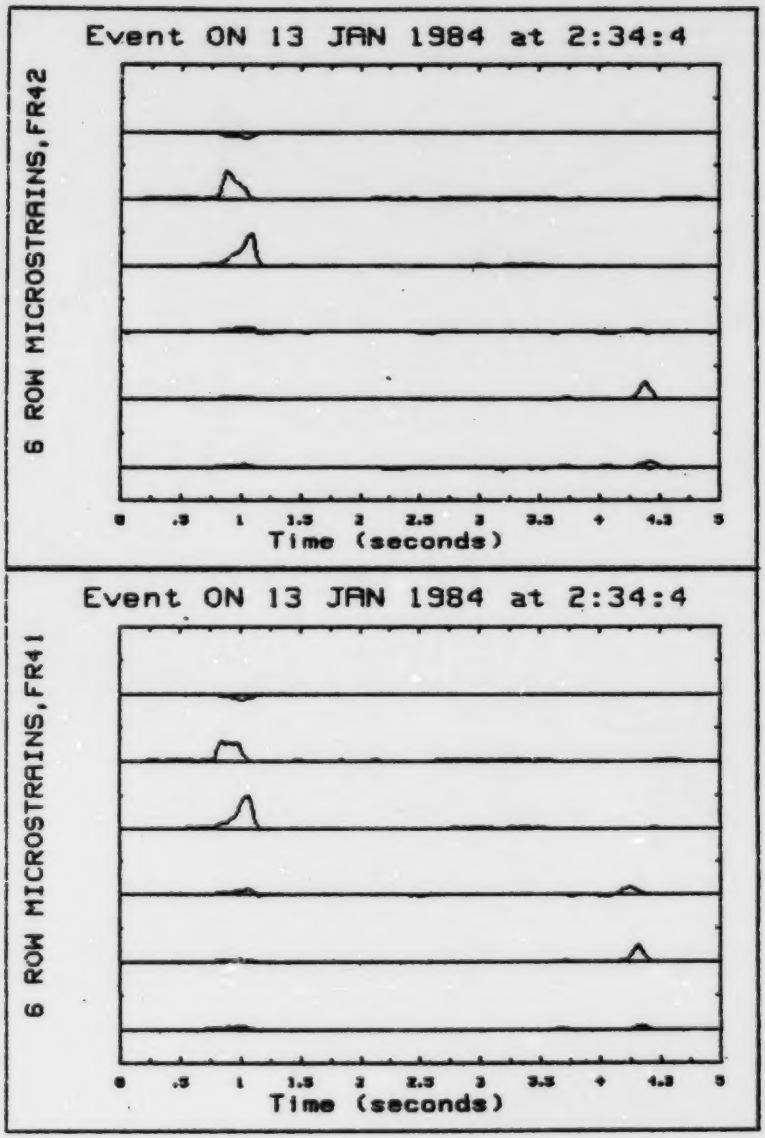
AVERAGE PITCH	.32	Deg Bow Up
AVERAGE ROLL	.96	Deg To Port
AVERAGE YAW RATE	.13	Deg/Sec Bow To Starboard

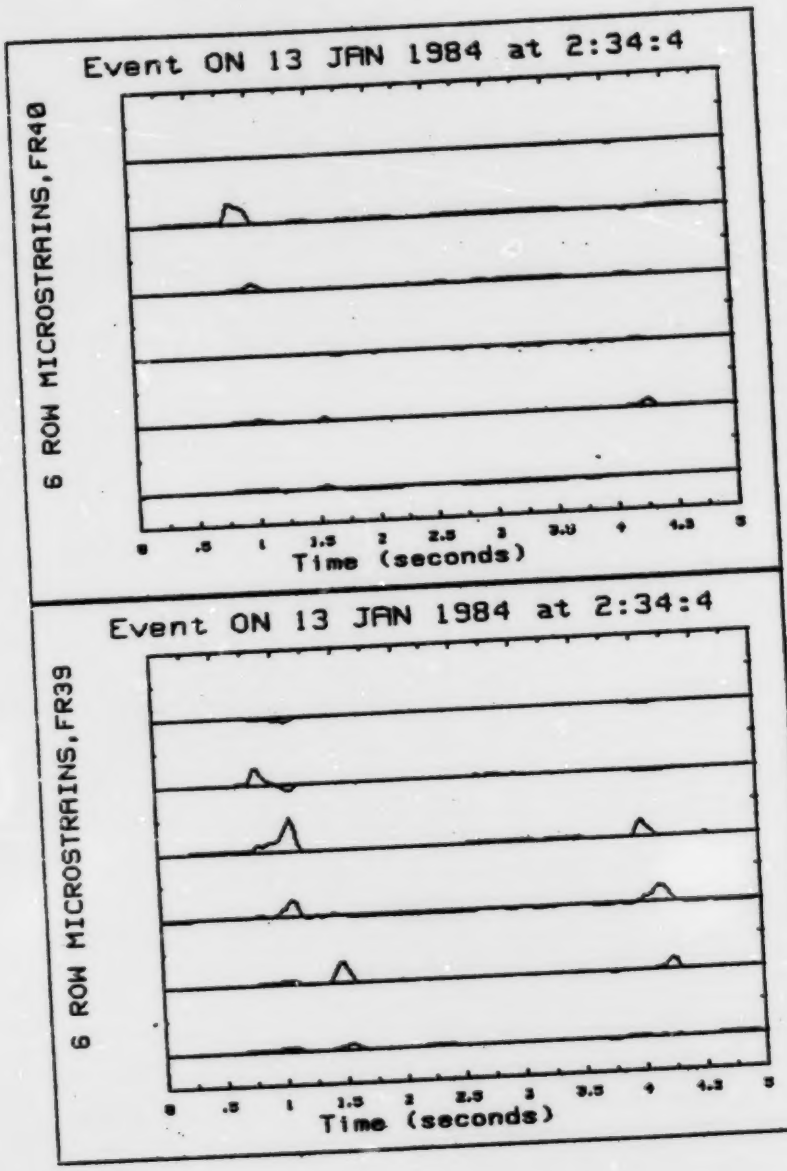
ZERO(1) = 1811 ZERO(2) = 2078
ZERO(3) = 3532 ZERO(4) = 2955

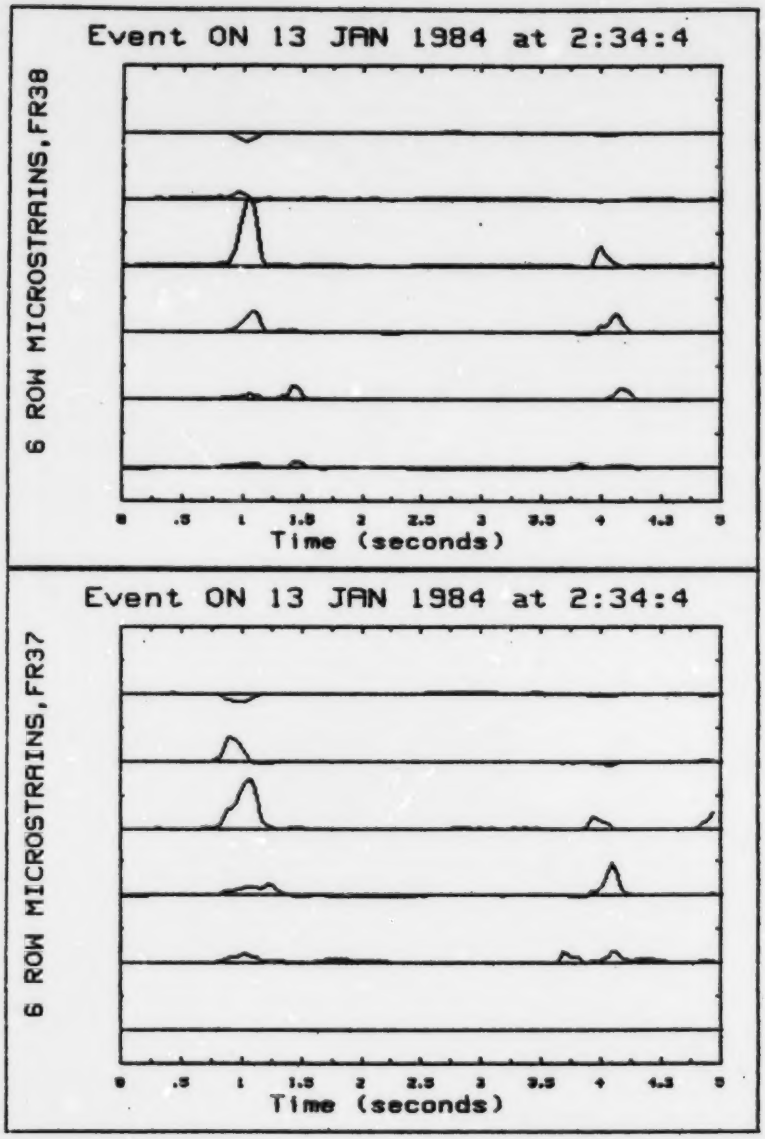


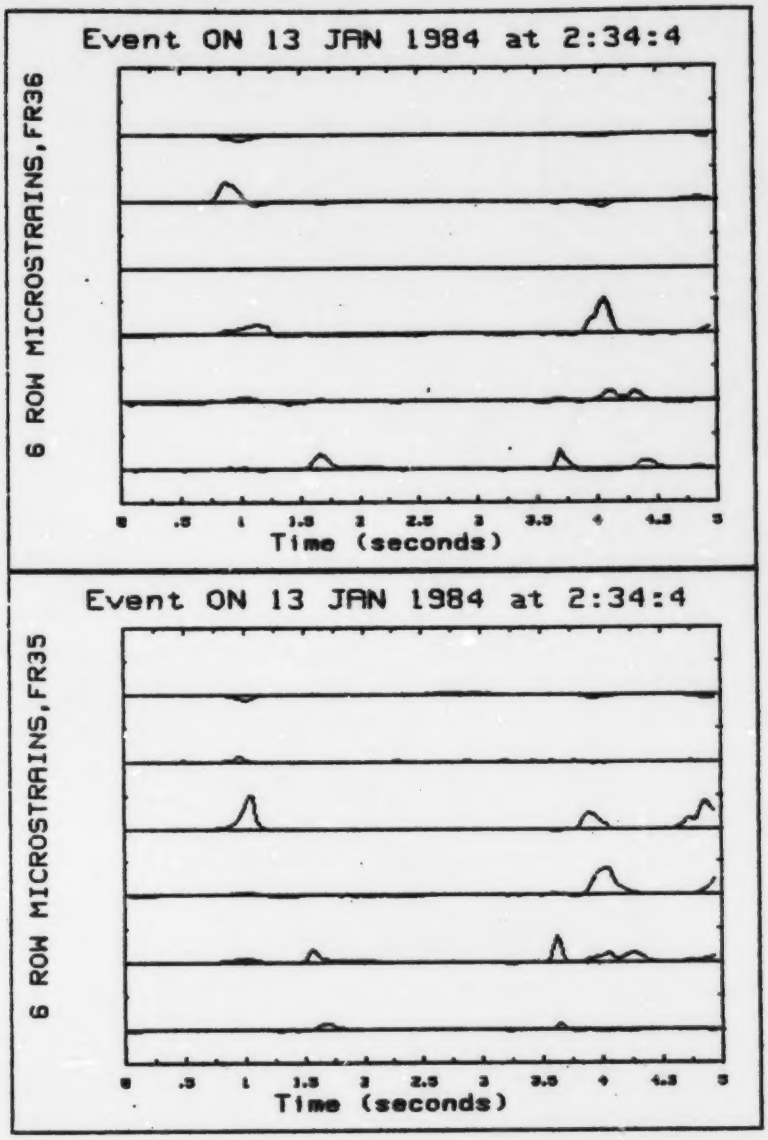

Event ON 12 JAN 1984 at 19:44:12
Roll (deg)
Time (seconds)
Event ON 12 JAN 1984 at 19:44:12
Yaw Rate (deg/sec)
Time (seconds)

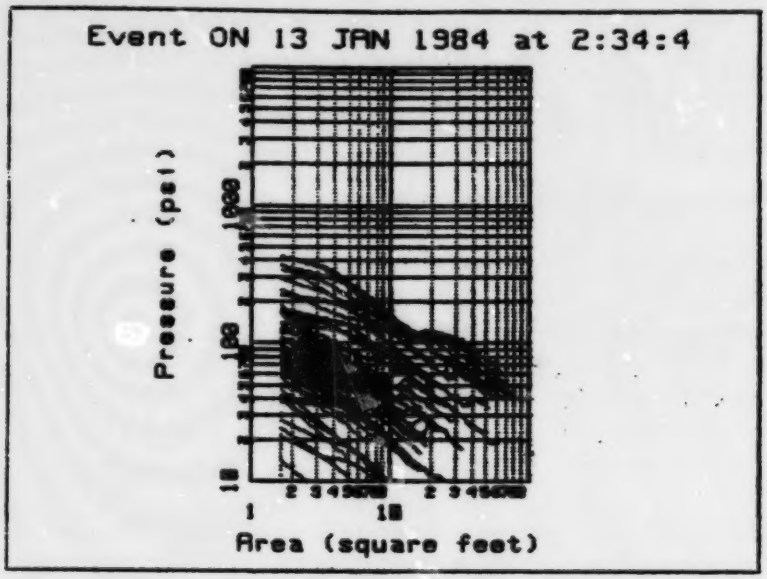

Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR44
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR43
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR42
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR41
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR38
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR37
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 13 JAN 1984 at 2:34:4
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 13 JAN 1984 AT 2:34:4
TAPE NUMBER 4 ; TRACK NUMBER 3 ; FILE NUMBER 32
PEAK STRAIN 201 ; THRESHOLD 150
AVERAGE SHIP SPEED 6.65 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 421 PSI; TIME FRAME 33; REAL TIME 1.03
FRAME 38; ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	421.00	352.00	256.00	207.00	174.00	151.00	134.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	119.00	107.00	116.00	115.00	121.00	122.00	119.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	116.00	114.00	110.00	105.00	100.00	107.00	102.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	99.00	95.00	92.00	89.00	86.00	83.00	80.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	78.00	76.00	75.00	73.00	72.00	71.00	69.00
Area	58.75	60.38	62.01	63.65			
Pressure	67.00	66.00	64.00	62.00			

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	421.00	231.00	159.00	121.00	100.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	421.00	352.00	256.00	195.00	194.00	180.00	181.00
LENGTH	10.67	12.00	13.33				
PRESSURE	169.00	18.00	17.00				

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 254 LONG TONS; TIME FRAME 33; REAL TIME 1.03
FRAME 38: ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

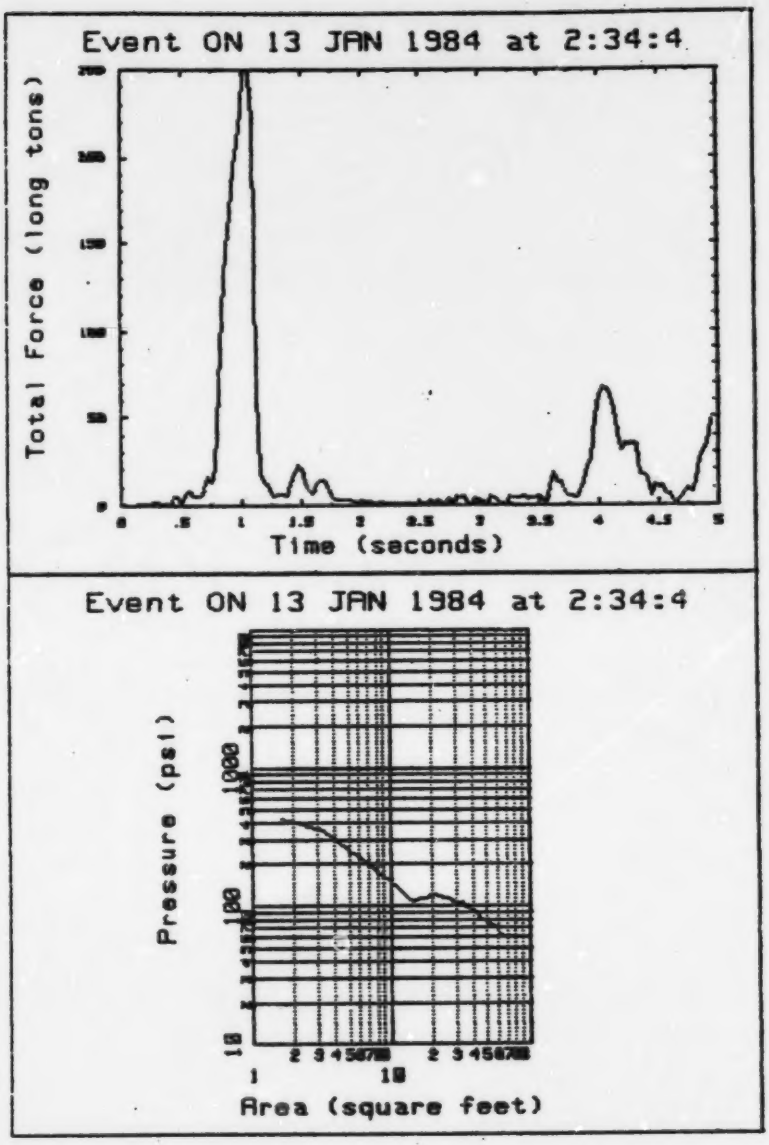
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	421.00	352.00	256.00	207.00	174.00	151.00	134.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	119.00	107.00	116.00	115.00	121.00	122.00	119.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	116.00	114.00	110.00	105.00	100.00	107.00	102.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	99.00	95.00	92.00	89.00	86.00	83.00	80.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	78.00	76.00	75.00	73.00	72.00	71.00	69.00
Area	58.75	60.38	62.01	63.65			
Pressure	67.00	66.00	64.00	62.00			

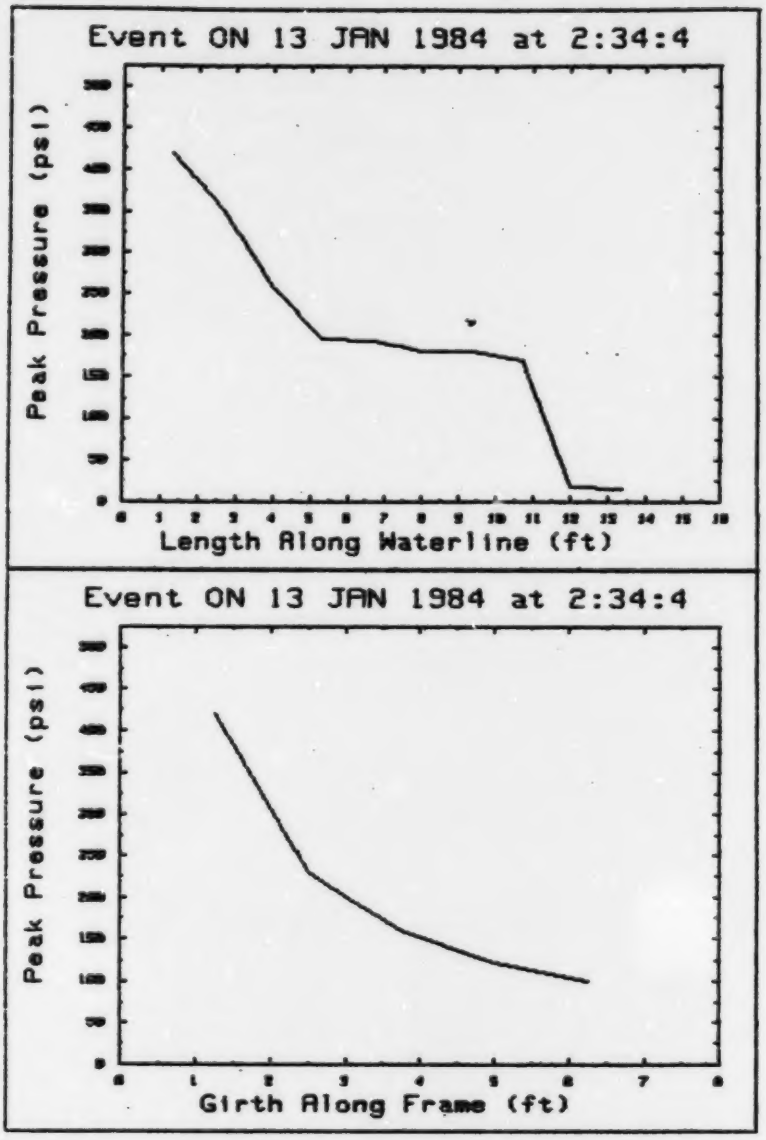
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

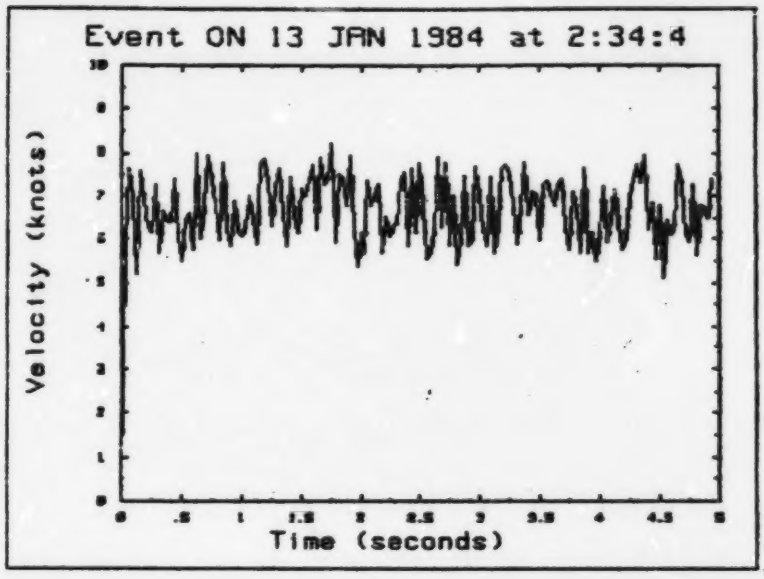
GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	421.00	231.00	159.00	121.00	100.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	421.00	352.00	256.00	195.00	194.00	180.00	181.00
LENGTH	10.67	12.00	13.33				
PRESSURE	169.00	18.00	17.00				

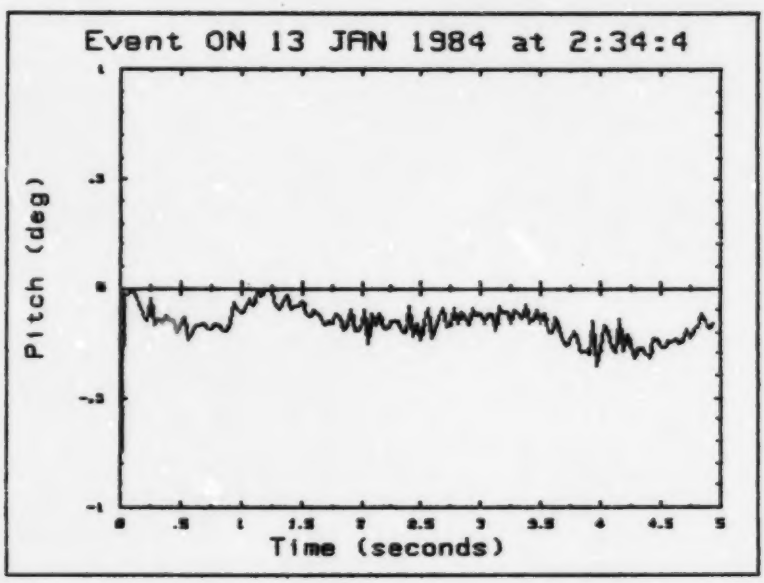

Event ON 13 JAN 1984 at 2:34:4
Total Force (long tons)
Time (seconds)
Event ON 13 JAN 1984 at 2:34:4
Pressure (psi)
Area (square feet)

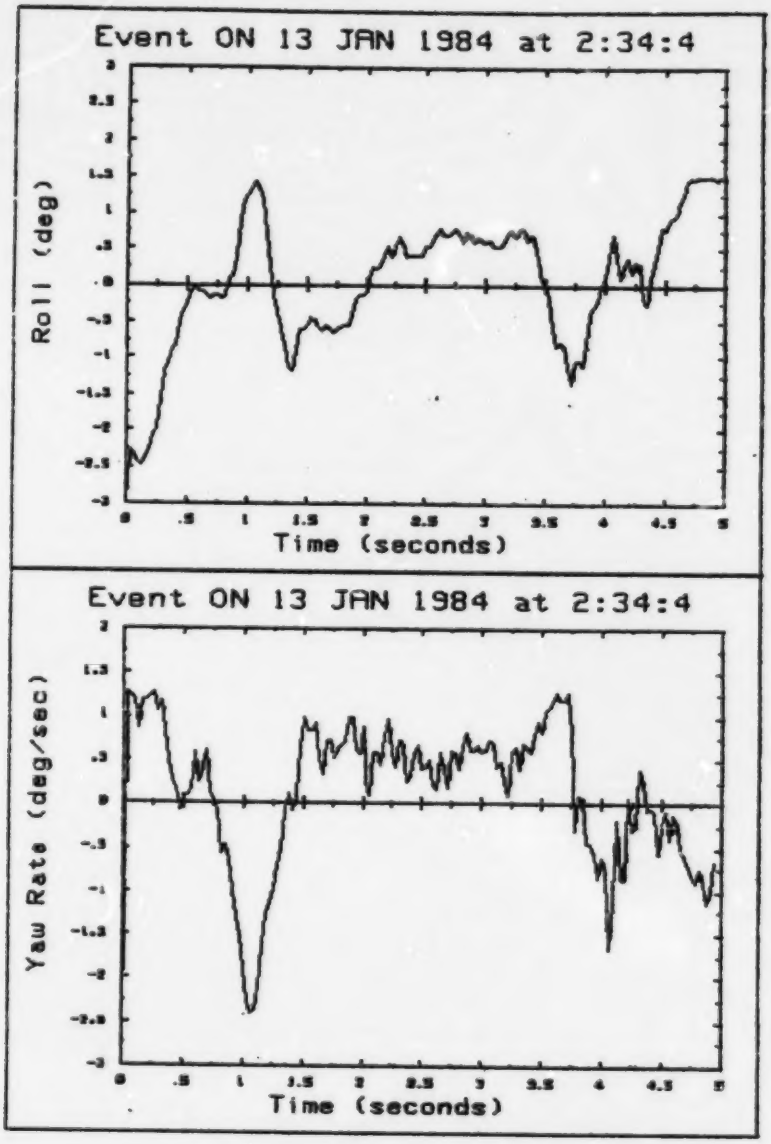

Event ON 13 JAN 1984 at 2:34:4
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 13 JAN 1984 at 2:34:4
Peak Pressure (psi)
Girth Along Frame (ft)

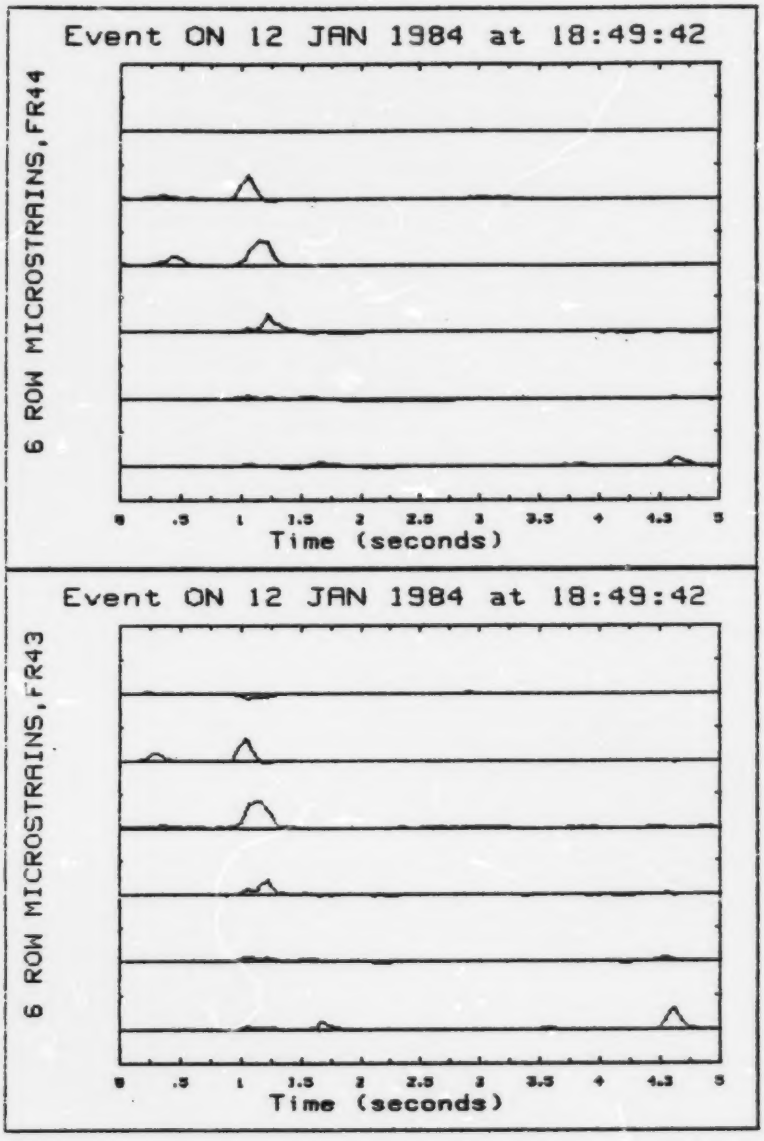

Event ON 13 JAN 1984 at 2:34:4
Velocity (knots)
Time (seconds)

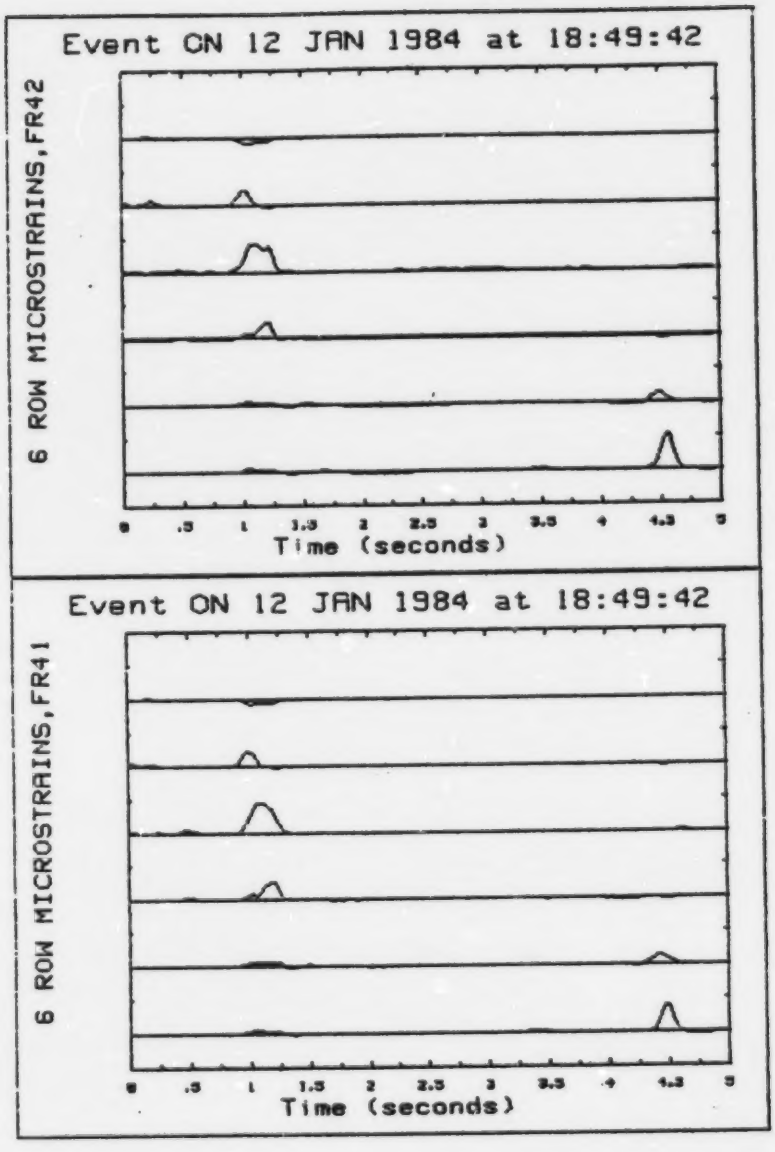
AVERAGE PITCH	.17 Deg Bow Down
AVERAGE ROLL	.48 Deg To Starboard
AVERAGE YAW RATE	.39 Deg/Sec Bow To Starboard

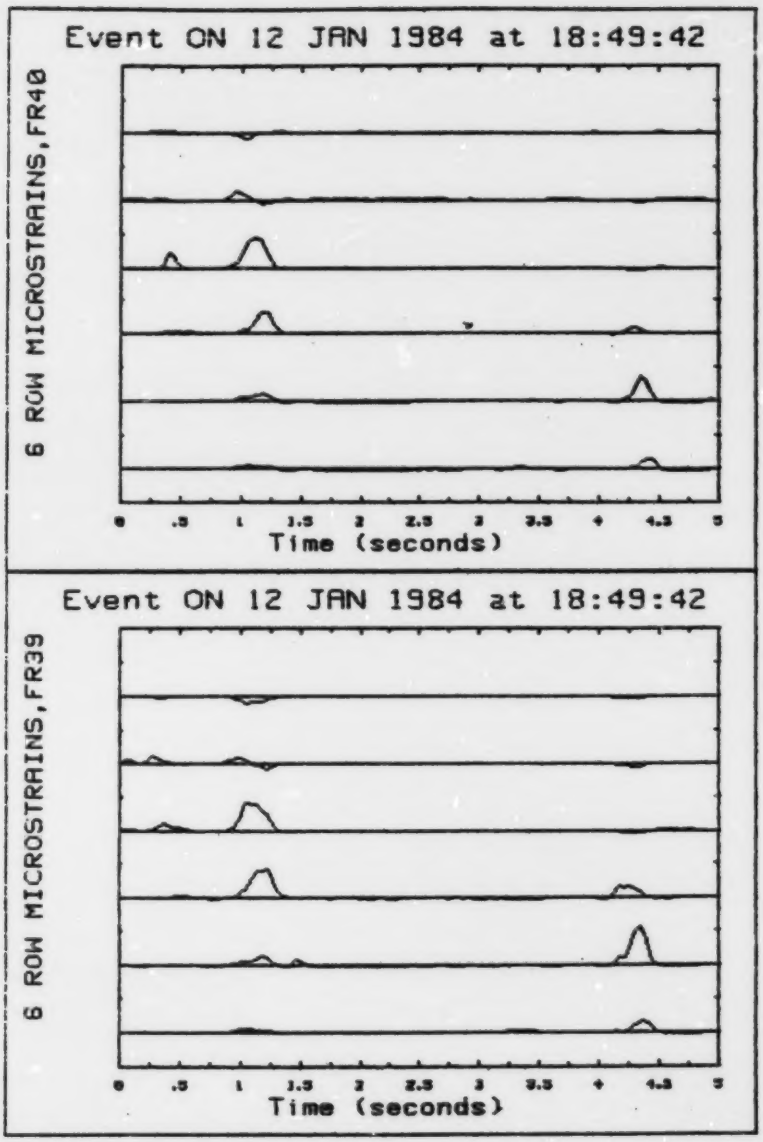
ZERO(1) = 1784	ZERO(2) = 2072
ZERO(3) = 3509	ZERO(4) = 3002

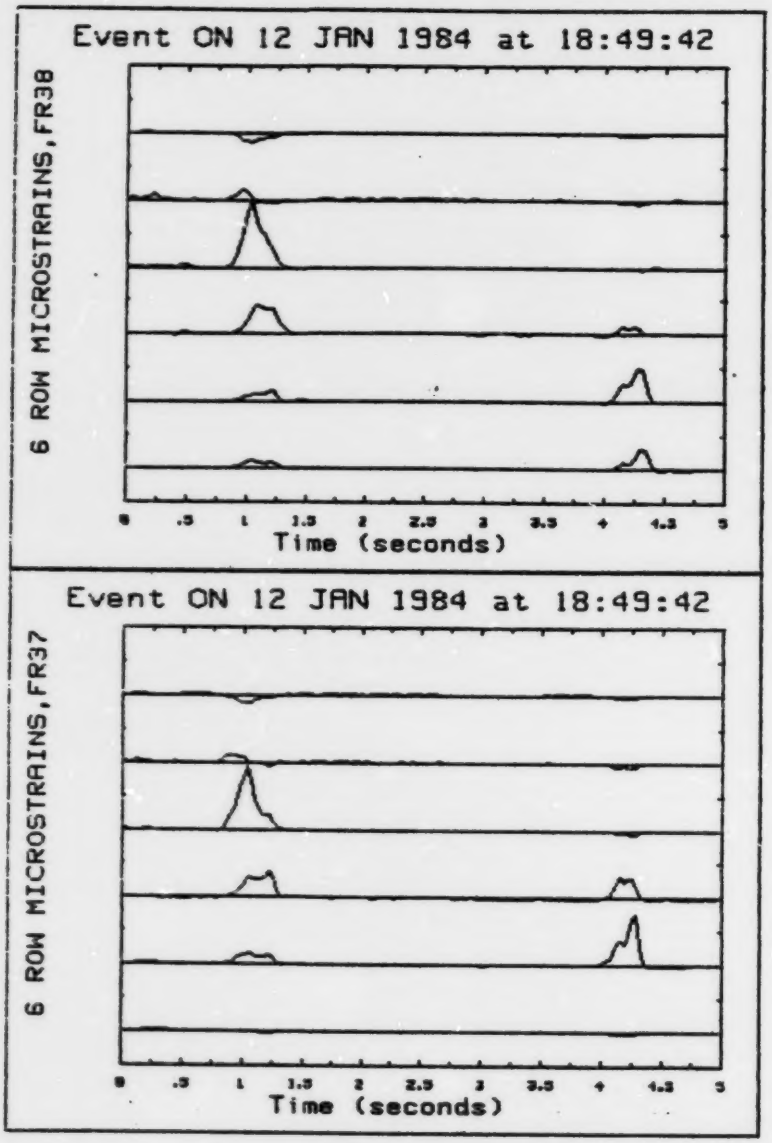


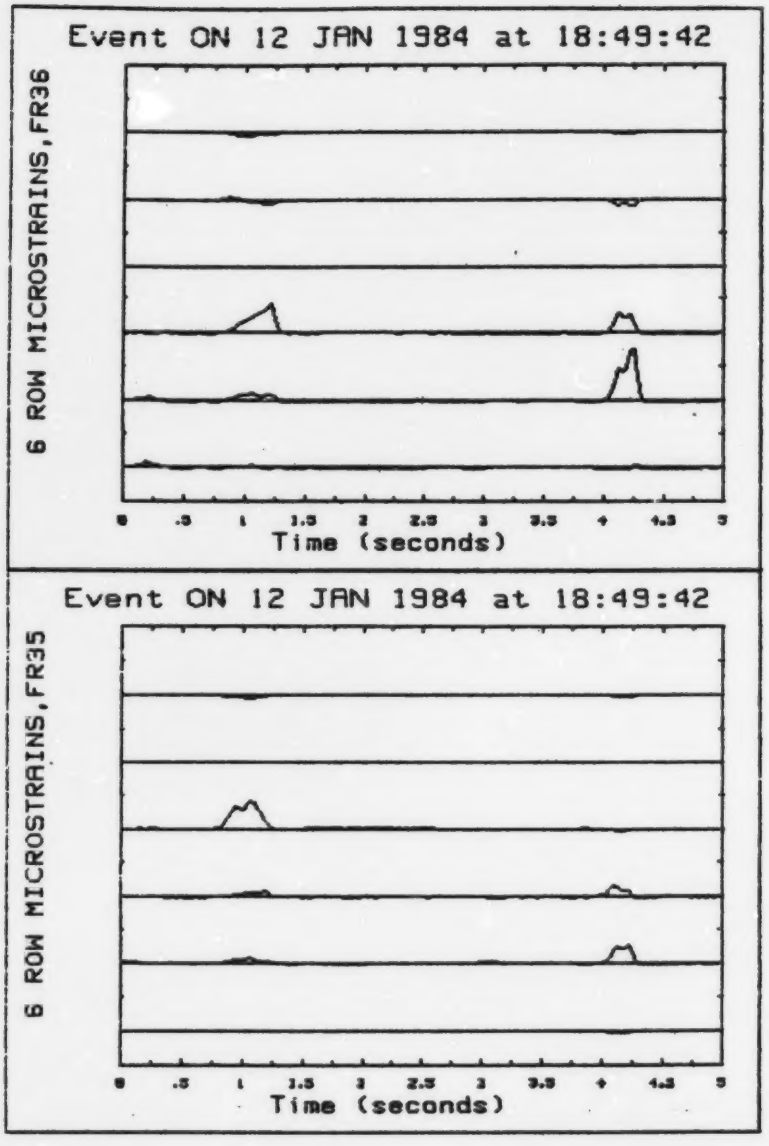

Event ON 13 JAN 1984 at 2:34:4
Roll (deg)
Time (seconds)
Event ON 13 JAN 1984 at 2:34:4
Yaw Rate (deg/sec)
Time (seconds)

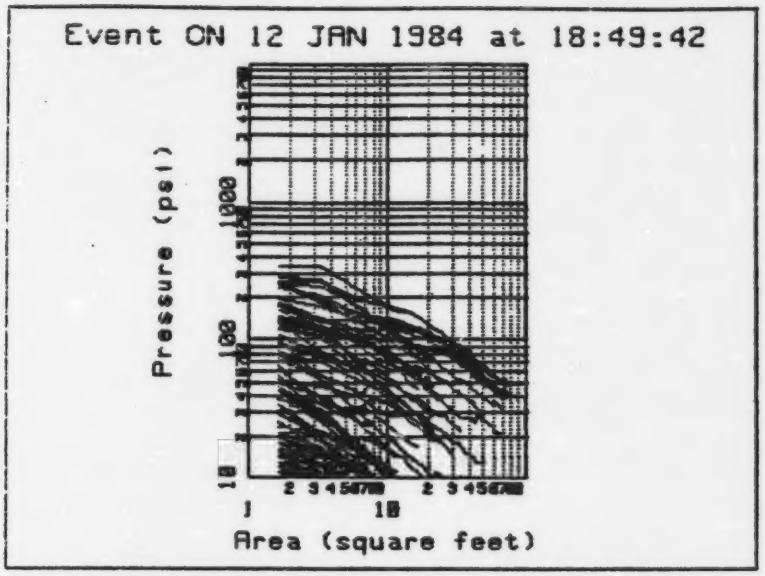

Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR44
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR43
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR42
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR41
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR38
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR37
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 12 JAN 1984 at 18:49:42
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 12 JAN 1984 AT 18:49:42
TAPE NUMBER 4 ; TRACK NUMBER 1 ; FILE NUMBER 49
PEAK STRAIN 172 ; THRESHOLD 125
AVERAGE SHIP SPEED 7.08 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 347 PSI: TIME FRAME 33; REAL TIME 1.03
FRAME 37; ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	347.00	345.00	266.00	222.00	197.00	178.00	165.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	162.00	157.00	148.00	139.00	130.00	123.00	117.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	111.00	105.00	100.00	95.00	91.00	87.00	84.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	80.00	77.00	75.00	73.00	70.00	68.00	66.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	64.00	62.00	60.00	59.00	57.00	56.00	55.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	54.00	54.00	54.00	52.00	51.00	50.00	49.00
Area	70.17	71.81	73.44	75.07			
Pressure	48.00	47.00	49.00	48.00			

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	347.00	191.00	139.00	106.00	90.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	347.00	345.00	266.00	222.00	197.00	175.00	157.00

LENGTH	10.67	12.00	13.33
PRESSURE	69.00	62.00	56.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 240 LONG TONS; TIME FRAME 34; REAL TIME 1.06
FRAME 37; ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

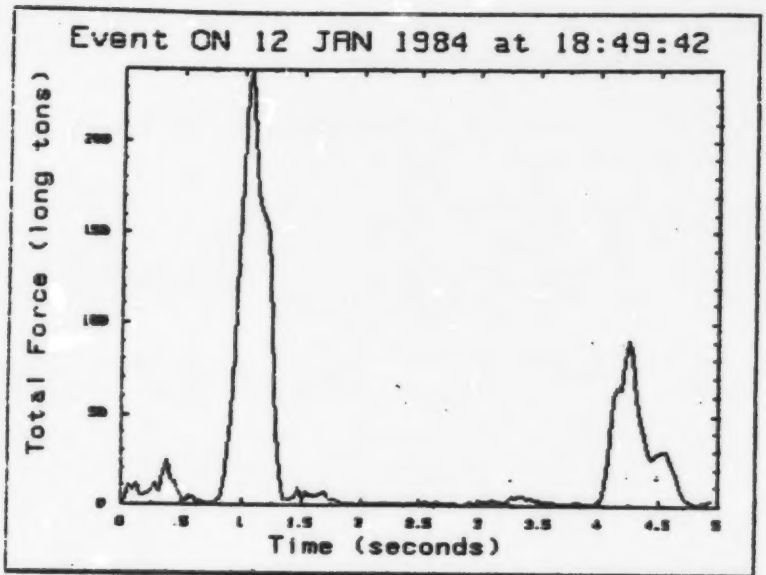
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	268.00	268.00	215.00	192.00	182.00	173.00	161.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	155.00	155.00	147.00	139.00	131.00	123.00	117.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	111.00	105.00	100.00	99.80	96.00	92.00	89.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	85.00	83.00	80.00	77.00	74.00	72.00	70.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	68.00	66.00	65.00	63.00	61.00	60.00	59.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	58.00	56.00	55.00	54.00	52.00	51.00	50.00
Area	70.17	71.81					
Pressure	49.00	52.00					

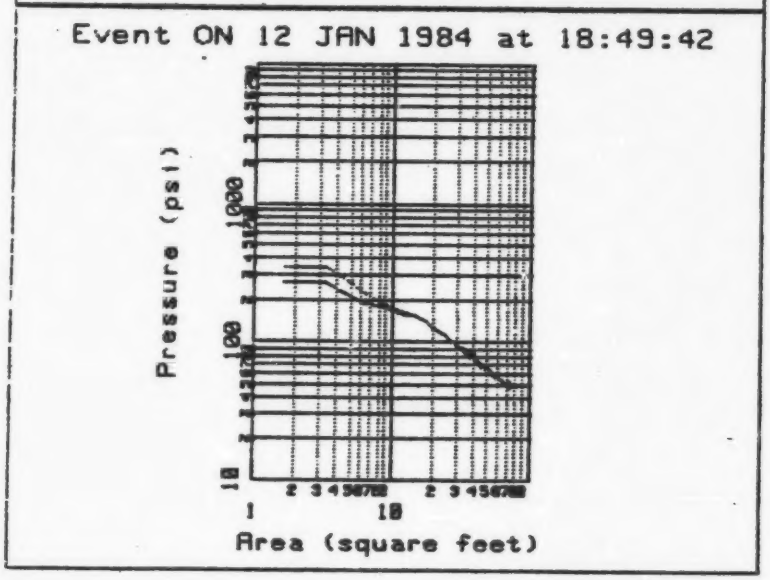
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

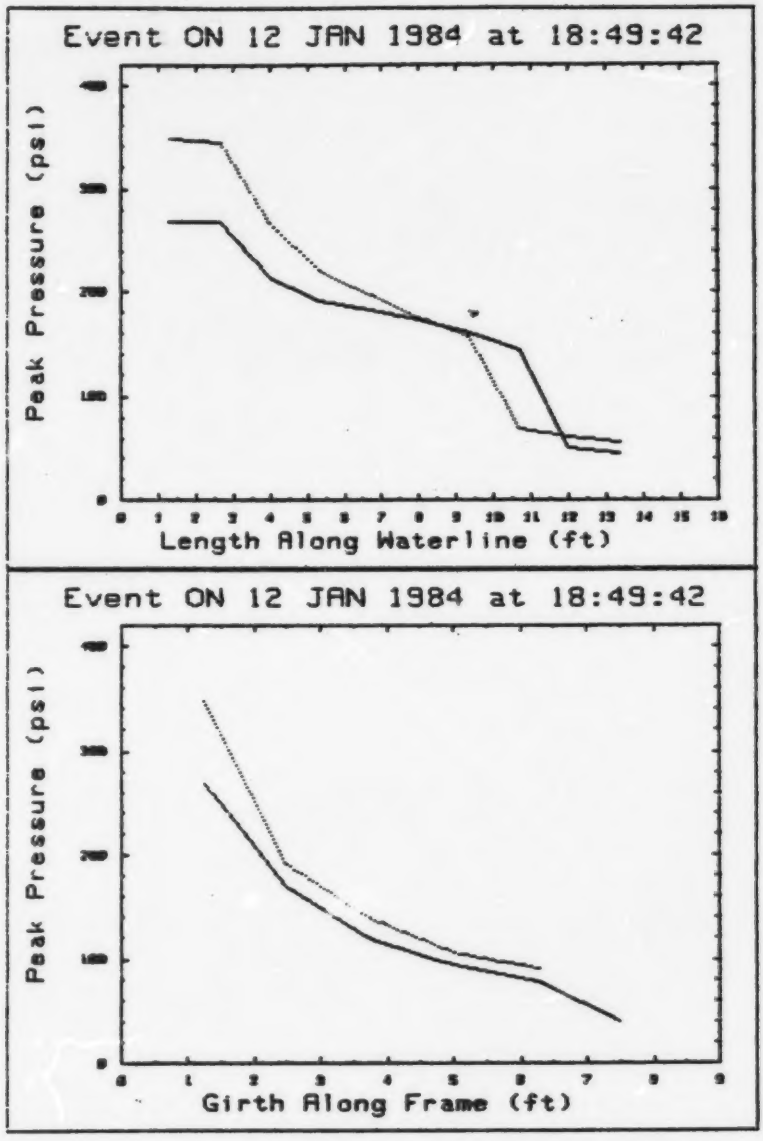
GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	268.00	169.00	119.00	93.00	78.00	39.00

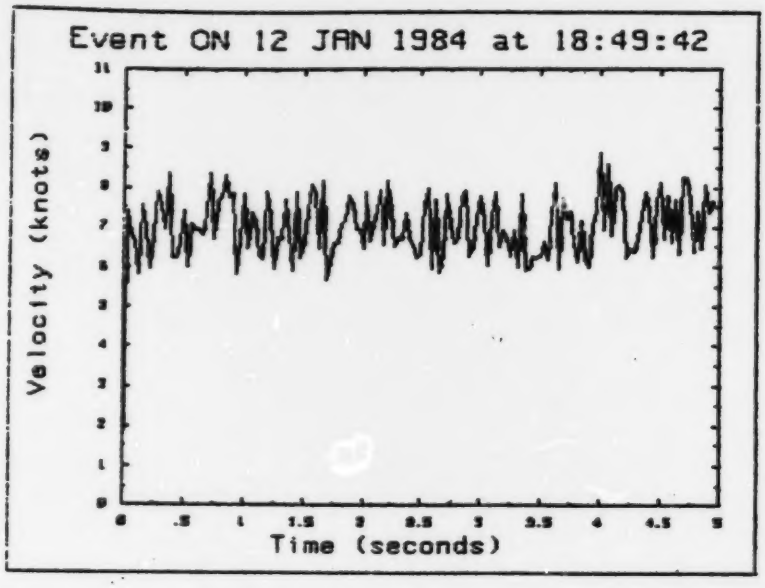
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	268.00	268.00	215.00	192.00	182.00	173.00	161.00
LENGTH	10.67	12.00	13.33				
PRESSURE	145.00	50.00	46.00				


Event ON 12 JAN 1984 at 18:49:42
Total Force (long tons)
Time (seconds)

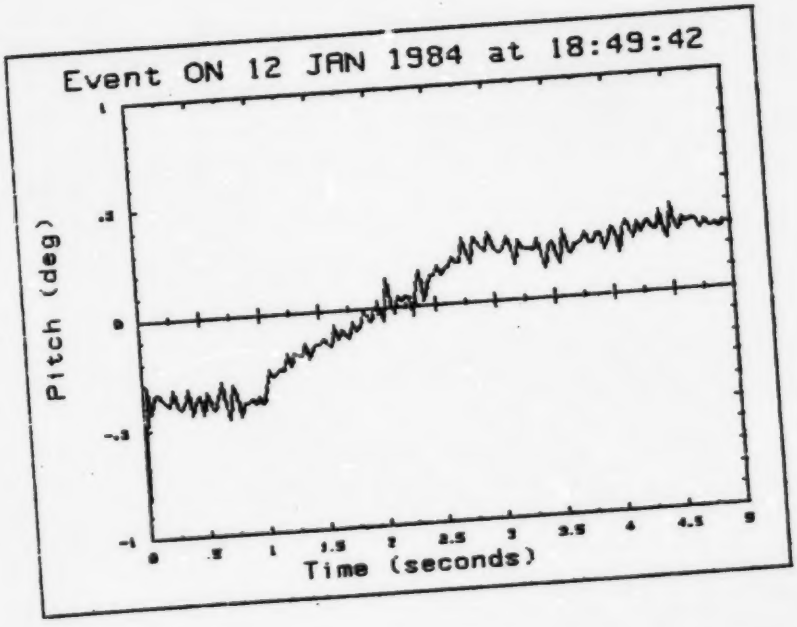

Event ON 12 JAN 1984 at 18:49:42
Pressure (psi)
Area (square feet)

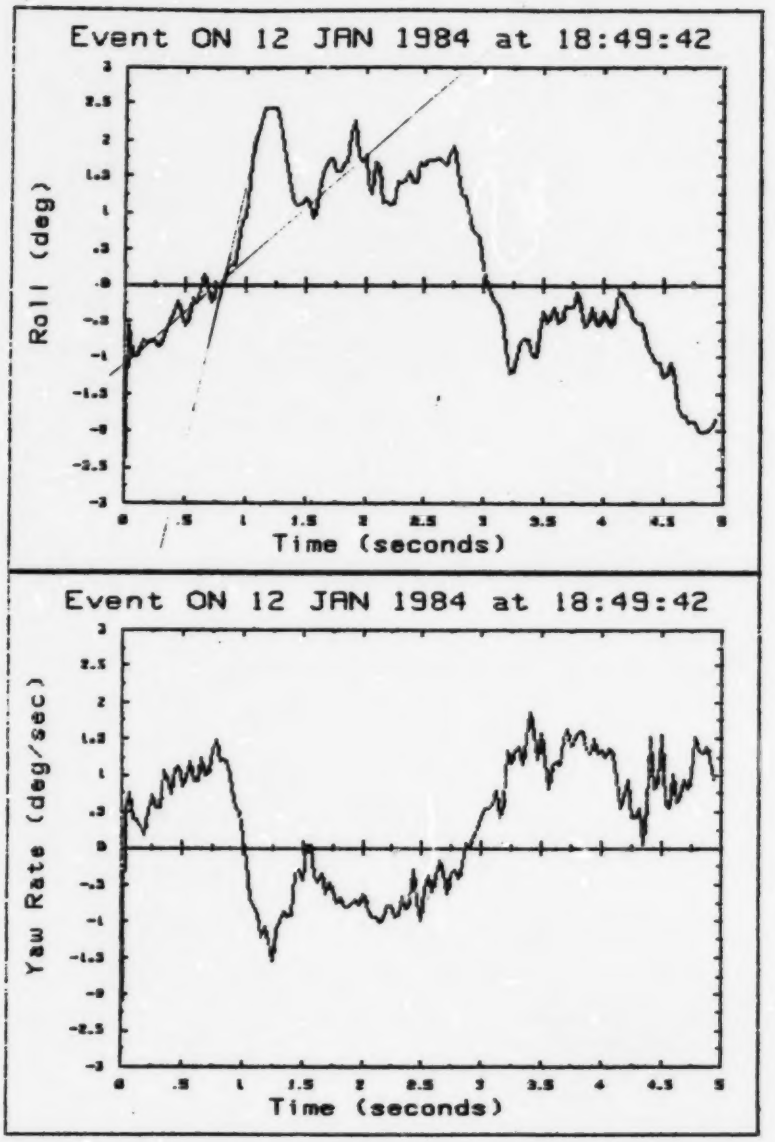

Event ON 12 JAN 1984 at 18:49:42
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 12 JAN 1984 at 18:49:42
Peak Pressure (psi)
Girth Along Frame (ft)

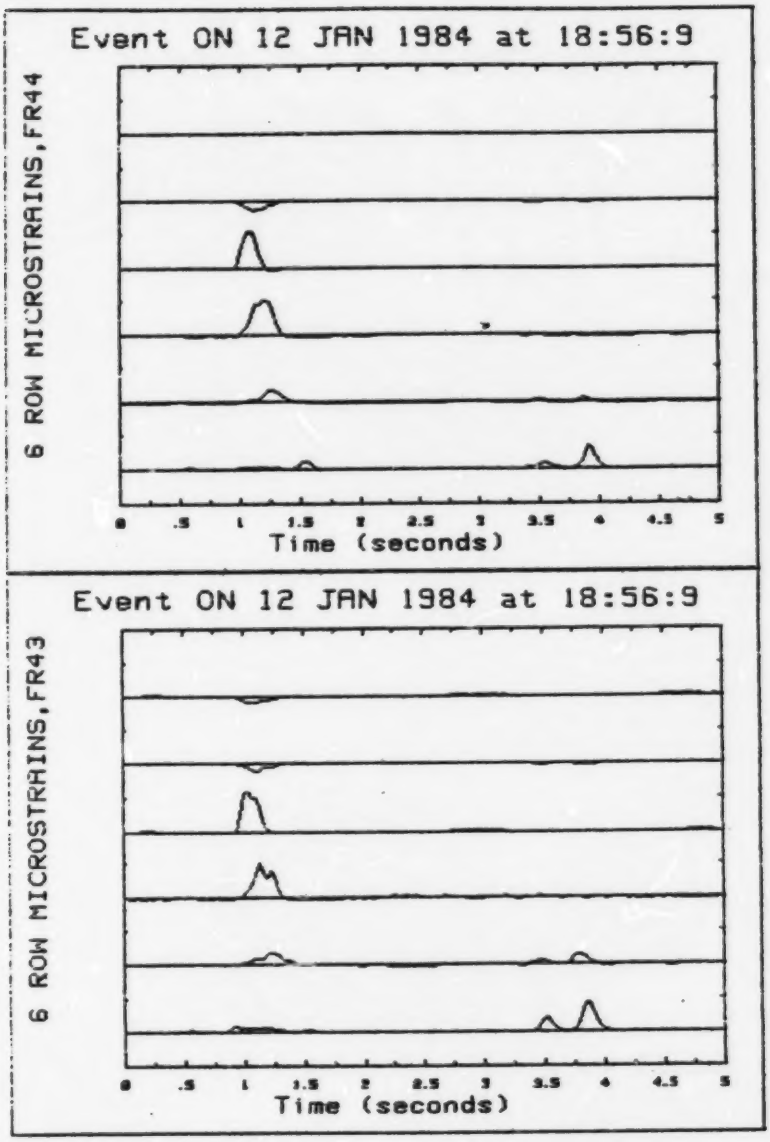

Event ON 12 JAN 1984 at 18:49:42
Velocity (knots)
Time (seconds)

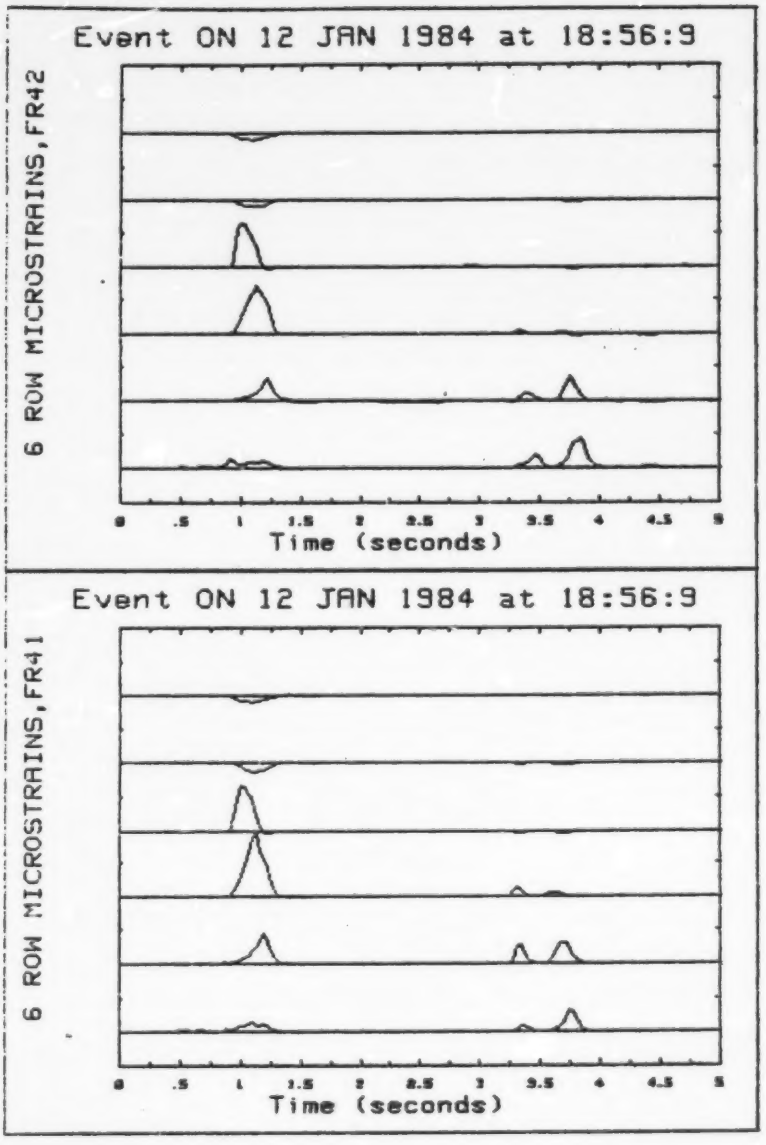
AVERAGE PITCH	.38 Deg Bow Down
AVERAGE ROLL	.34 Deg To Starboard
AVERAGE YAW RATE	.98 Deg/Sec Bow To Starboard

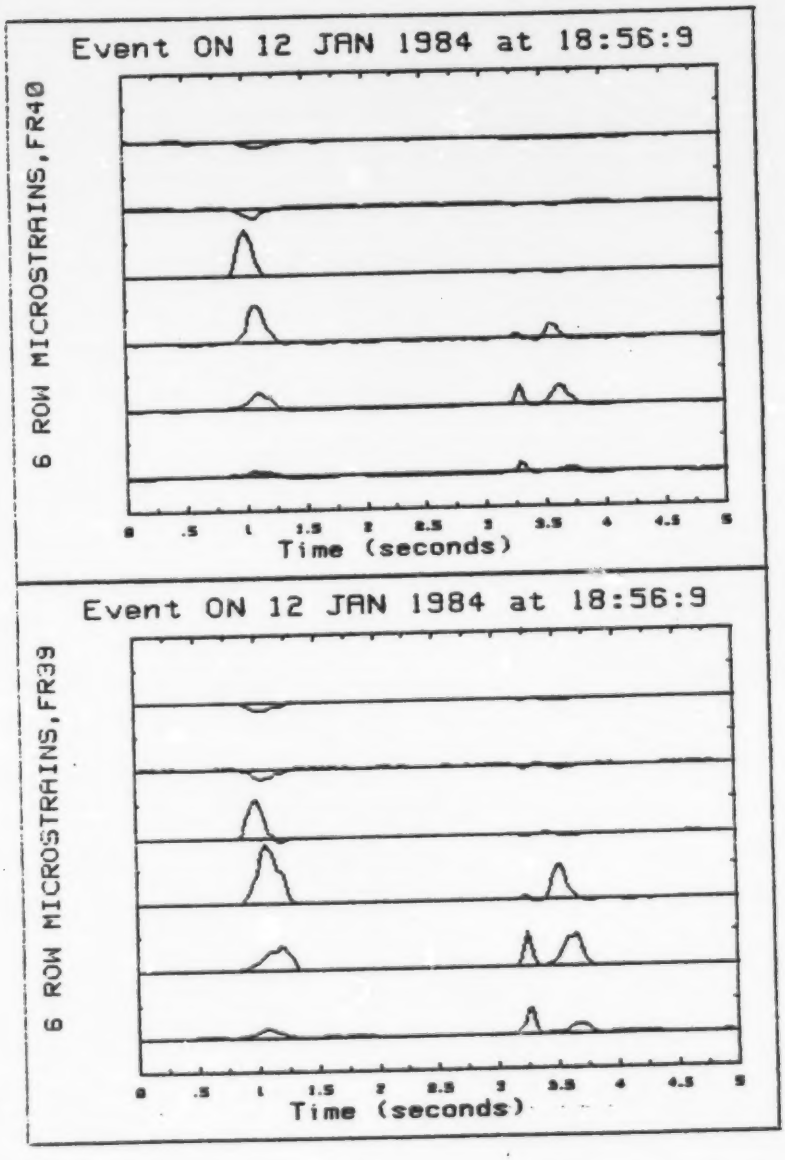
ZERO(1) = 1811
ZERO(2) = 2078
ZERO(3) = 3532
ZERO(4) = 2955

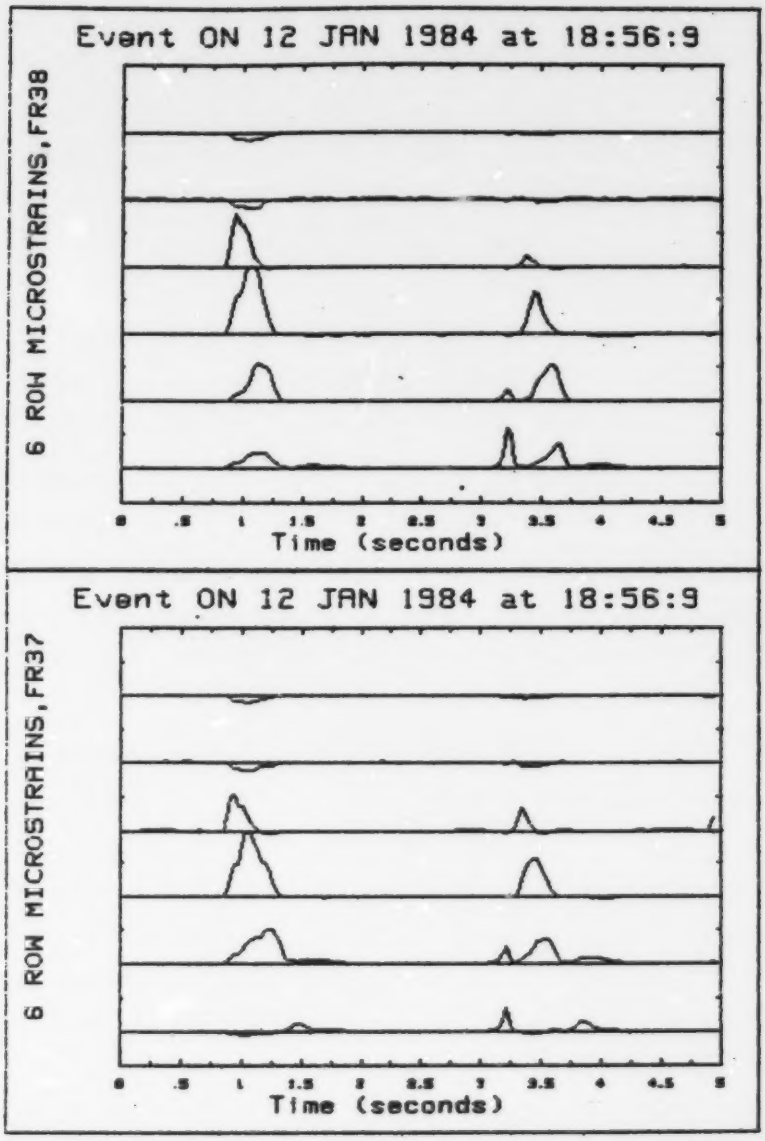


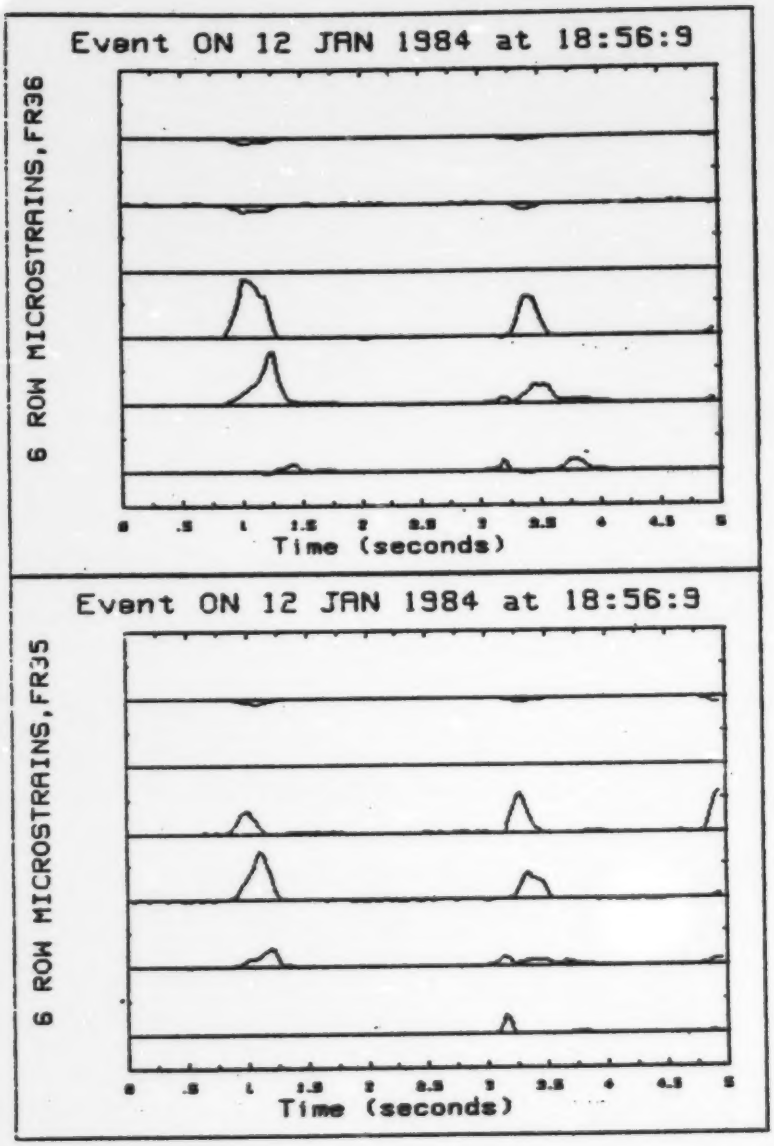

Event ON 12 JAN 1984 at 18:49:42
Roll (deg)
Time (seconds)
Event ON 12 JAN 1984 at 18:49:42
Yaw Rate (deg/sec)
Time (seconds)

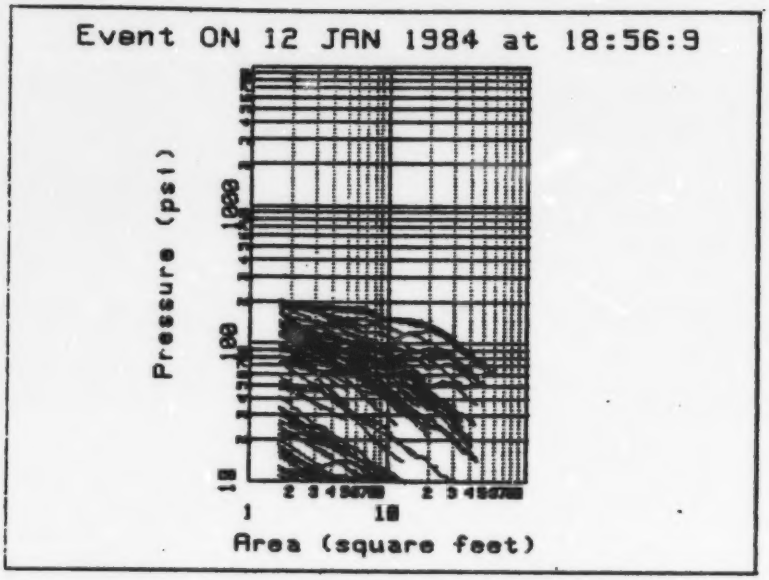

Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR44
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR43
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR42
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR41
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR40
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR39
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 12 JAN 1984 at 18:56:9
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 12 JAN 1984 AT 18:56:9
TAPE NUMBER 4 ; TRACK NUMBER 1 ; FILE NUMBER 66
PEAK STRAIN 130 ; THRESHOLD 125
AVERAGE SHIP SPEED 7.34 Knots

RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 209 PSI: TIME FRAME 40; REAL TIME 1.25
FRAME 36; ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	209.00	162.00	121.00	105.00	91.00	82.00	73.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	67.00	61.00	56.00	52.00	51.00	50.00	51.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	54.00	53.00	53.00	51.00	49.00	47.00	45.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	
Pressure	43.00	41.00	40.00	38.00	37.00	36.00	

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	209.00	111.00	79.00	16.00	15.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	209.00	162.00	121.00	105.00	88.00	77.00	72.00
LENGTH	10.67	12.00	13.33				
PRESSURE	66.00	61.00	57.00				

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 228 LONG TONS; TIME FRAME 34; REAL TIME 1.06
FRAME 37; ROW 6

AVERAGE PRESSURE (psi) vs AREA (square feet)

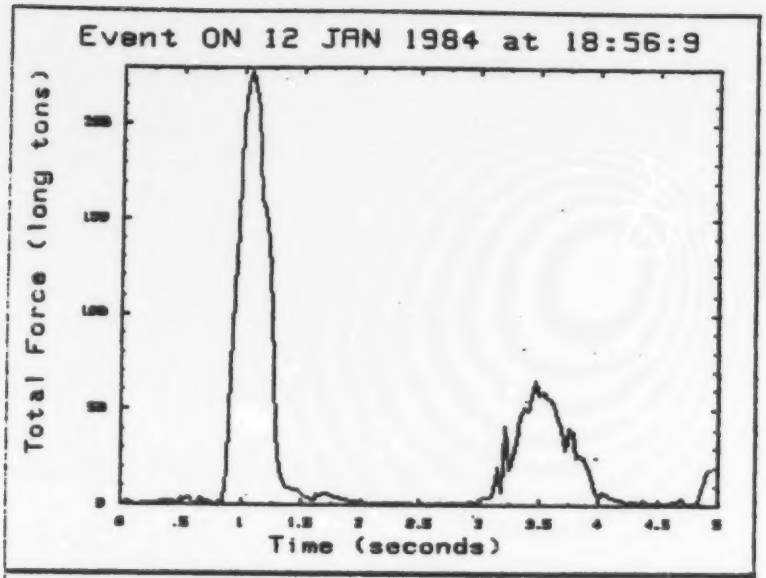
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	189.00	188.00	185.00	181.00	168.00	152.00	149.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	144.00	141.00	139.00	141.00	138.00	134.00	129.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	123.00	117.00	112.00	107.00	103.00	99.00	96.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	93.00	89.00	86.00	83.00	80.00	78.00	75.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	
Pressure	74.00	72.00	69.00	67.00	65.00	64.00	

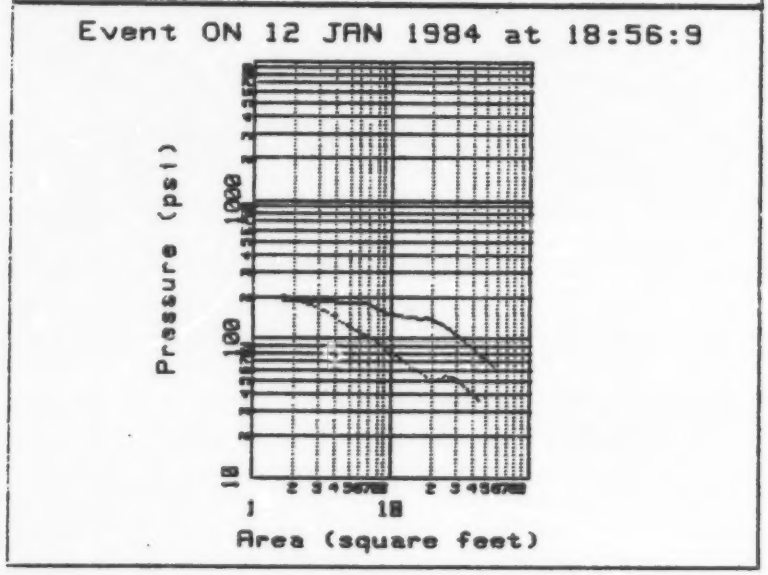
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

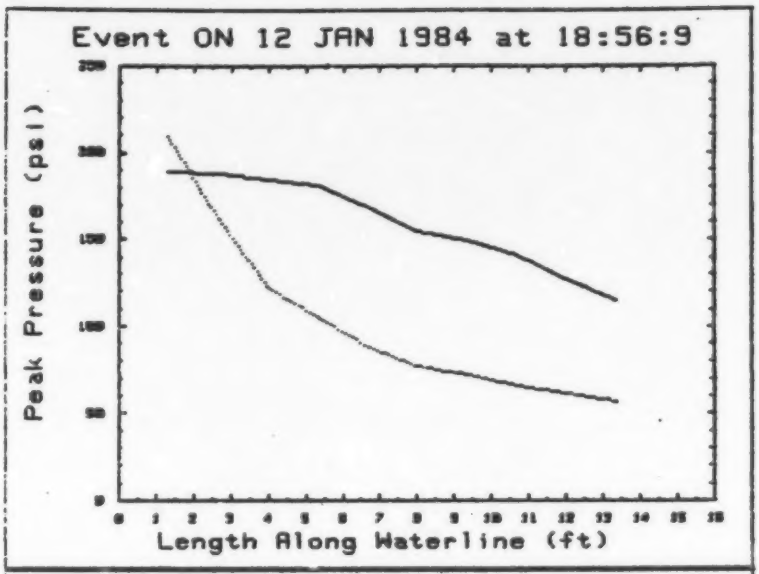
GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	189.00	123.00	89.00	77.00	62.00

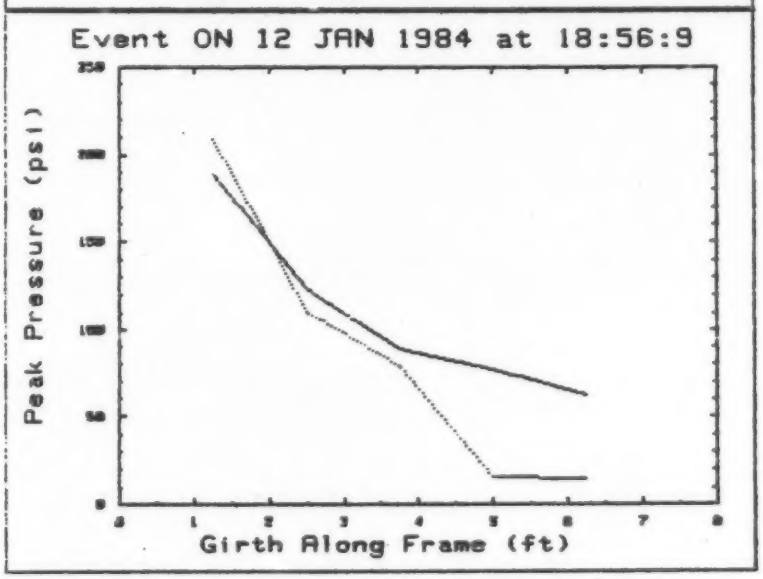
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

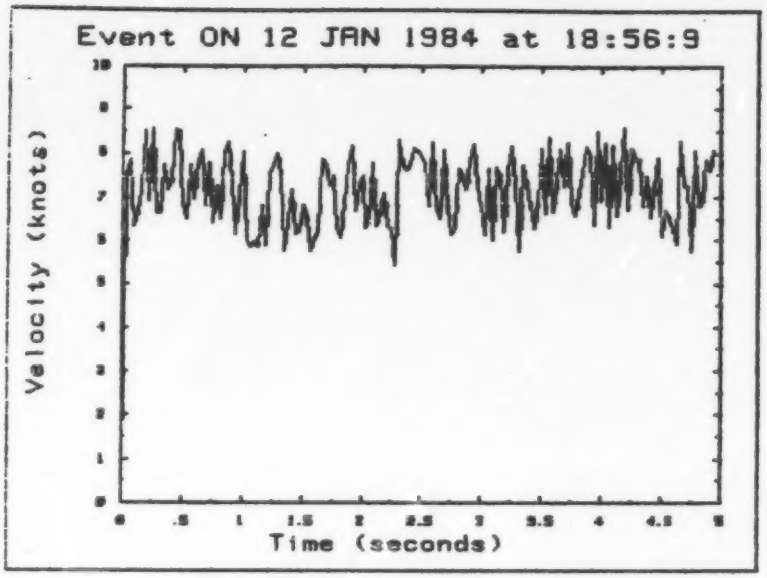
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	189.00	188.00	185.00	181.00	168.00	154.00	149.00
LENGTH	10.67	12.00	13.33				
PRESSURE	141.00	127.00	115.00				


Event ON 12 JAN 1984 at 18:56:9
Total Force (long tons)
Time (seconds)


Event ON 12 JAN 1984 at 18:56:9
Pressure (psi)
Area (square feet)

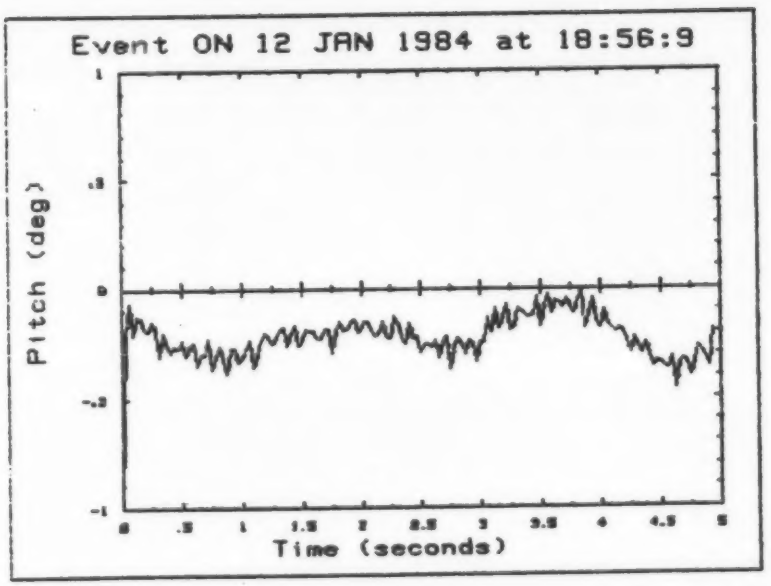

Event ON 12 JAN 1984 at 18:56:9
Peak Pressure (psi)
Length Along Waterline (ft)

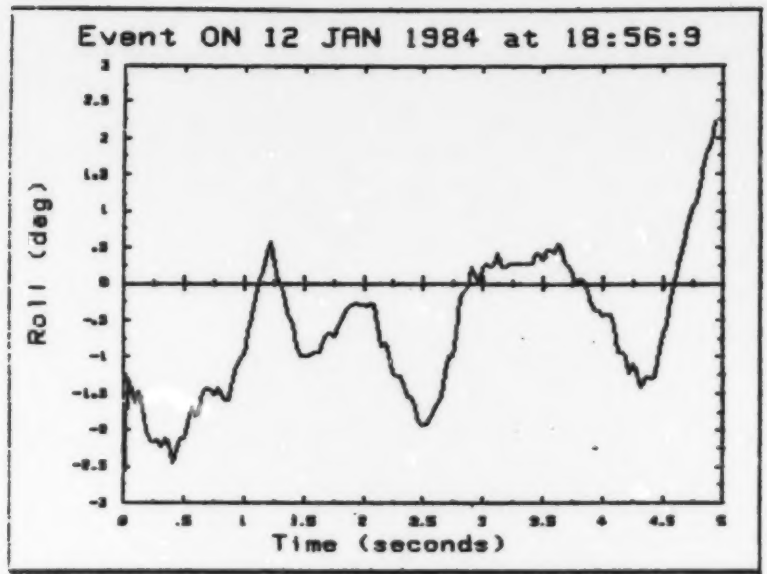

Event ON 12 JAN 1984 at 18:56:9
Peak Pressure (psi)
Girth Along Frame (ft)

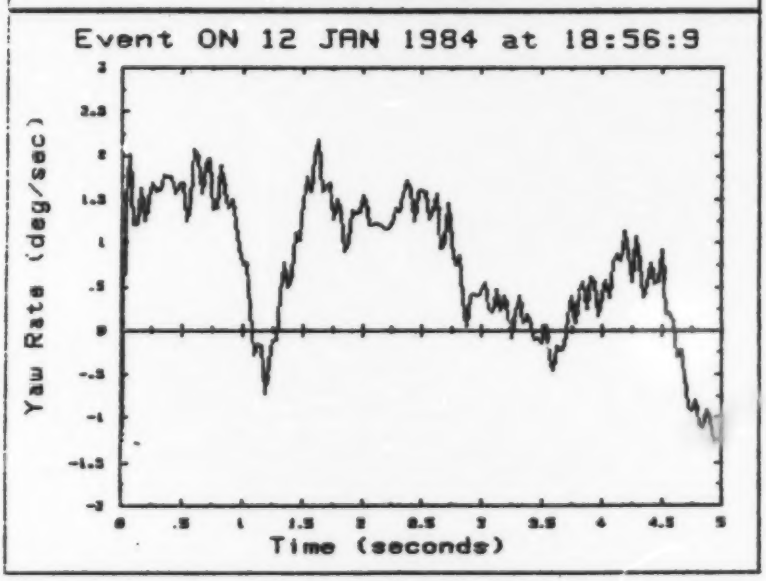

Event ON 12 JAN 1984 at 18:56:9
Velocity (knots)
Time (seconds)

AVERAGE PITCH	.27	Deg Bow Down
AVERAGE ROLL	1.92	Deg To Starboard
AVERAGE YAW RATE	1.69	Deg/Sec Bow To Starboard

ZERO(1) =	1811	ZERO(2) =	2078
ZERO(3) =	3532	ZERO(4) =	2955

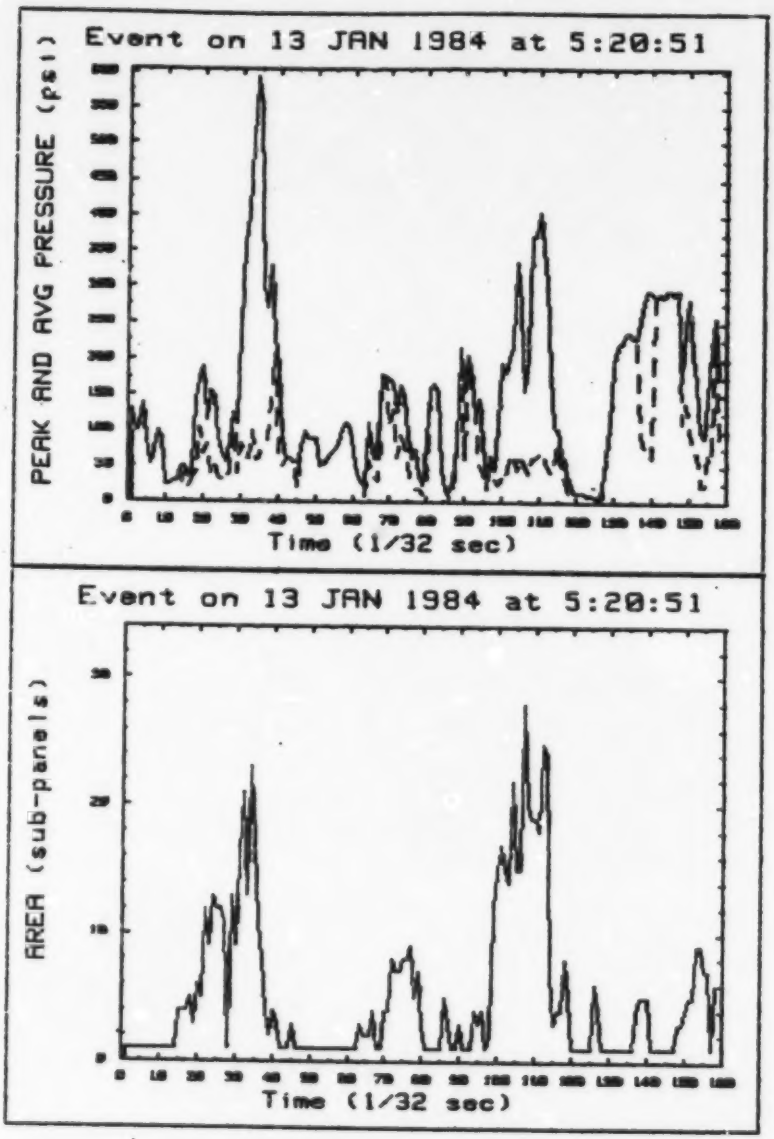


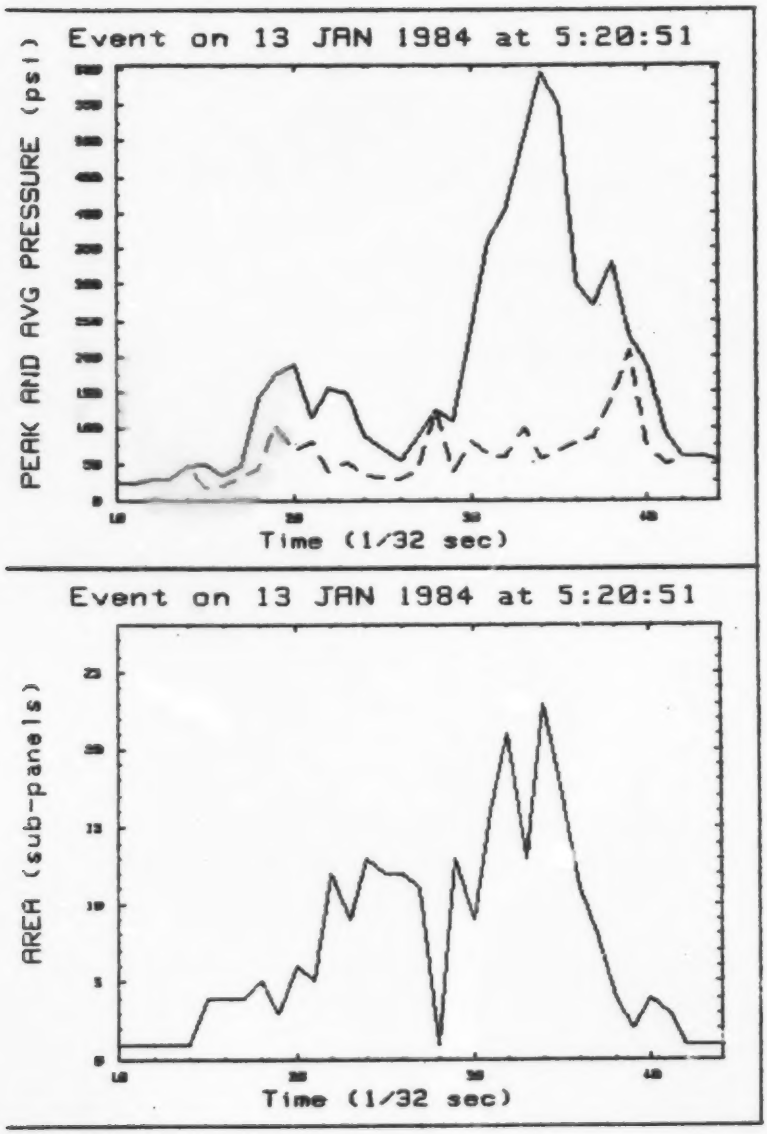

Event ON 12 JAN 1984 at 18:56:9
Roll (deg)
Time (seconds)

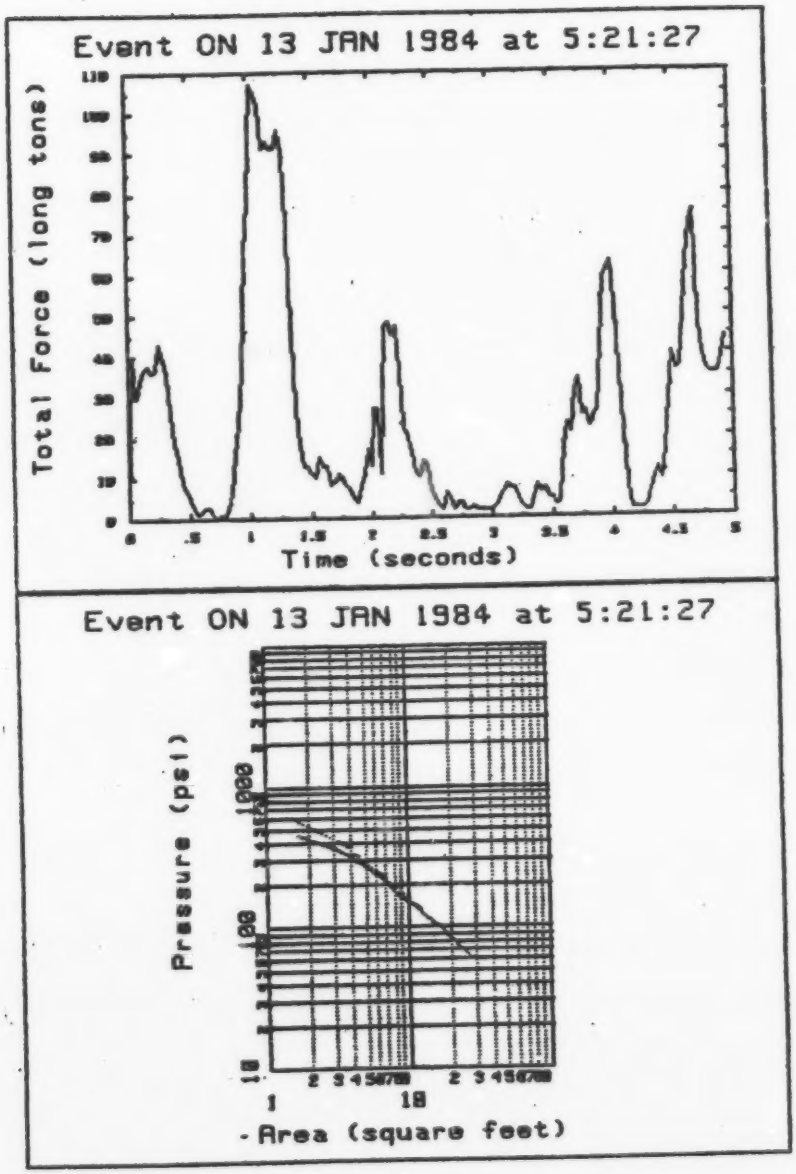

Event ON 12 JAN 1984 at 18:56:9
Yaw Rate (deg/sec)
Time (seconds)

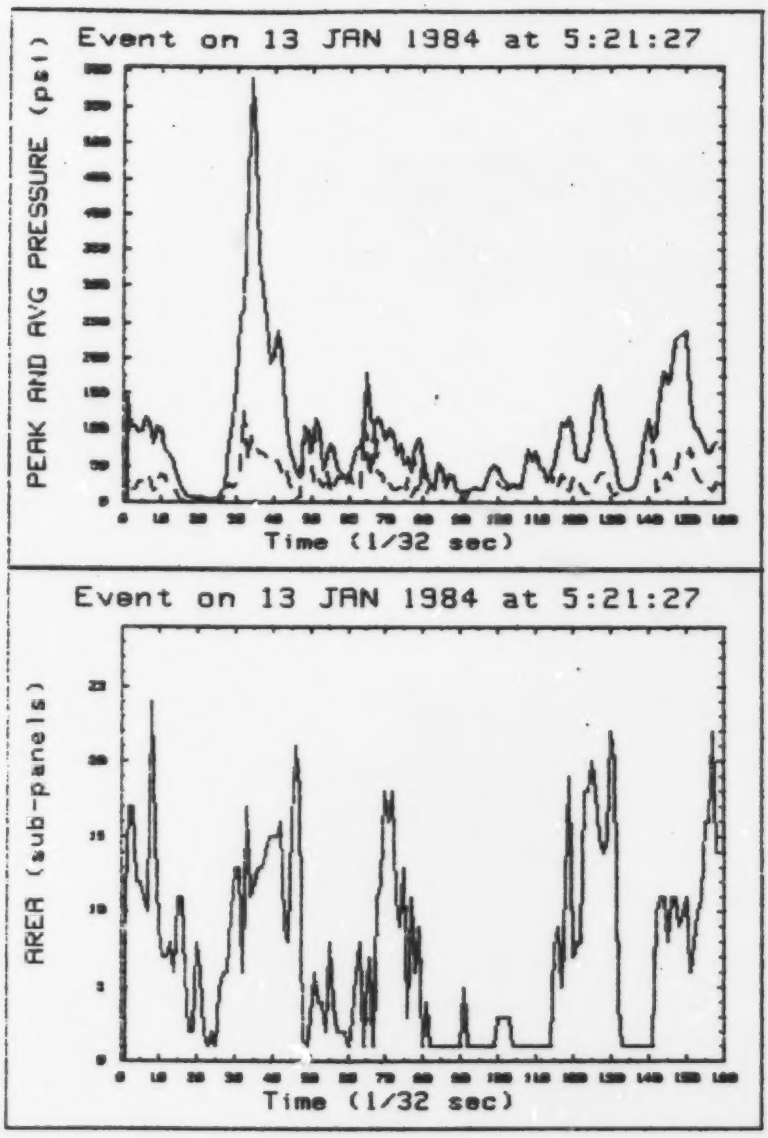
APPENDIX E

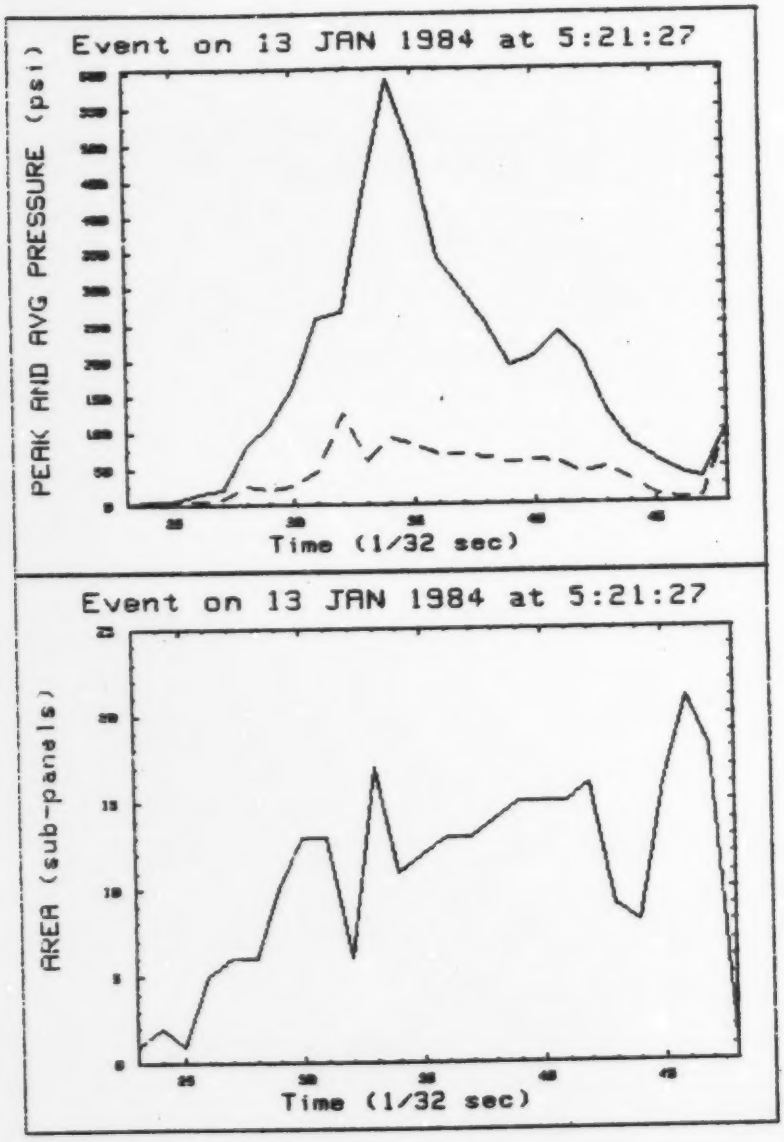
THREE EVENTS SHOWING THE TIME VARIATION OF PEAK AND AVERAGE PRESSURE AND CONTACT AREA

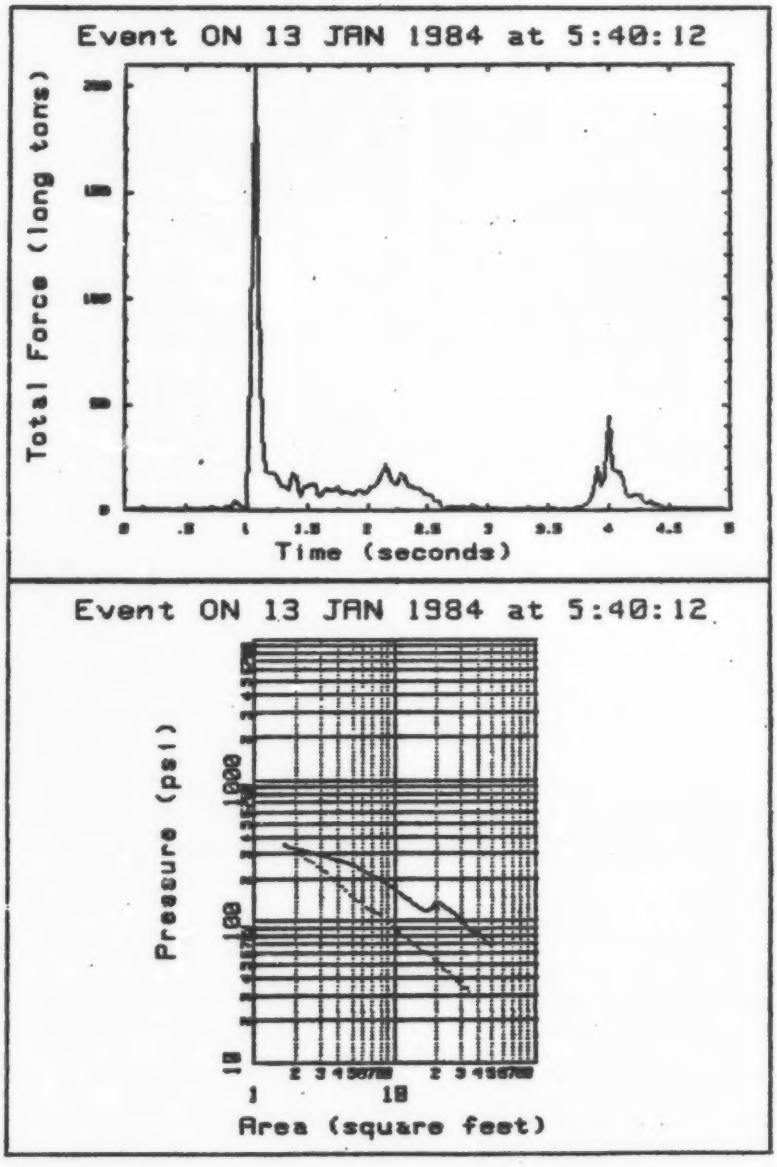

Event on 13 JAN 1984 at 5:20:51
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 13 JAN 1984 at 5:20:51
AREA (sub-panels)
Time (1/32 sec)

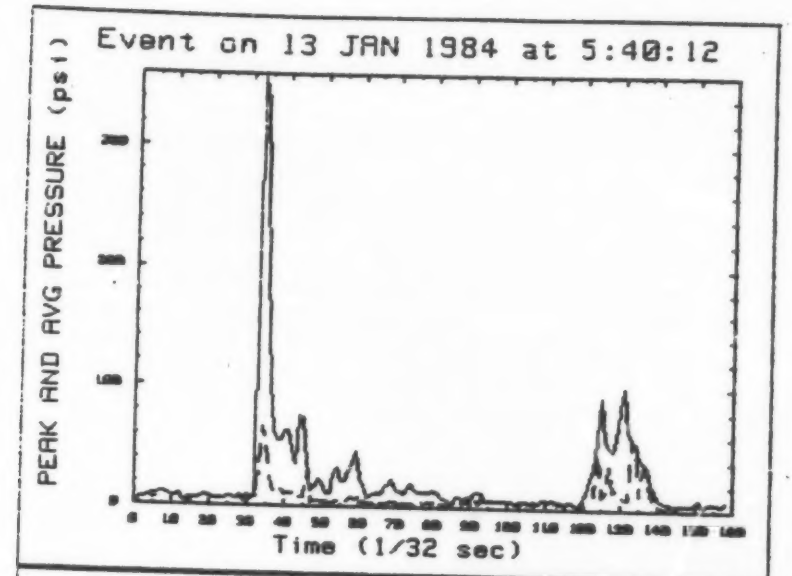

Event on 13 JAN 1984 at 5:20:51
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 13 JAN 1984 at 5:20:51
AREA (sub-panels)
Time (1/32 sec)

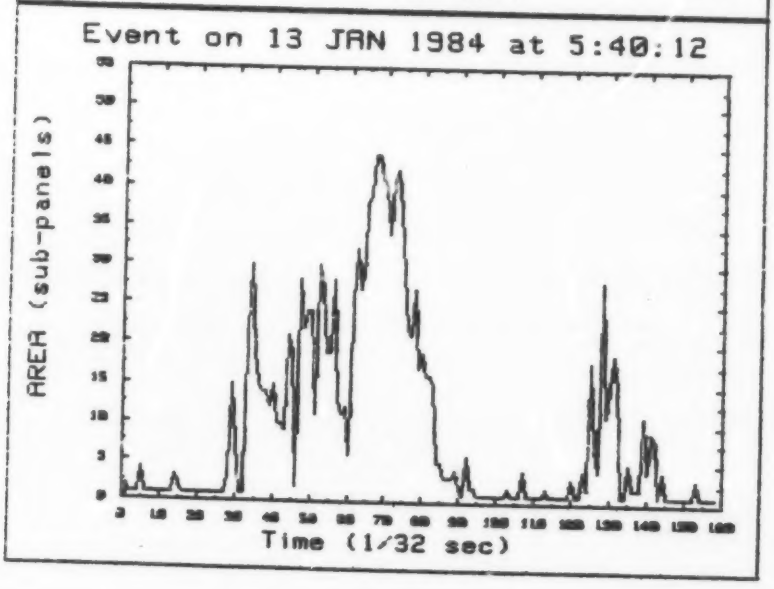

Event ON 13 JAN 1984 at 5:21:27
Total Force (long tons)
Time (seconds)
Event ON 13 JAN 1984 at 5:21:27
Pressure (psi)
1000
100
10
1
10
Area (square feet)

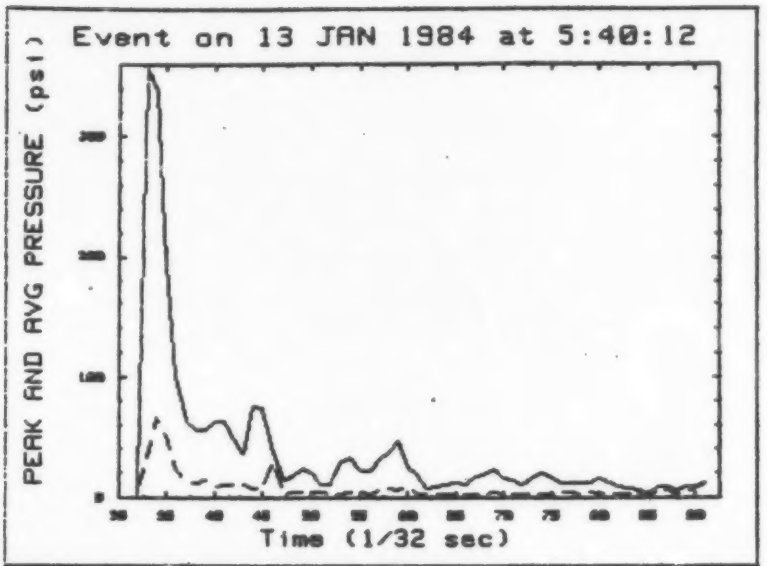

Event on 13 JAN 1984 at 5:21:27
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 13 JAN 1984 at 5:21:27
AREA (sub-panels)
Time (1/32 sec)

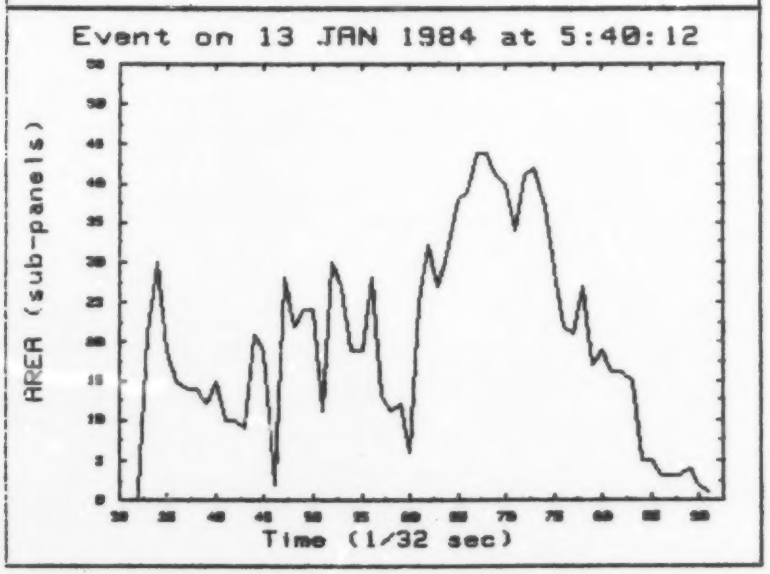

Event on 13 JAN 1984 at 5:21:27
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 13 JAN 1984 at 5:21:27
AREA (sub-panels)
Time (1/32 sec)

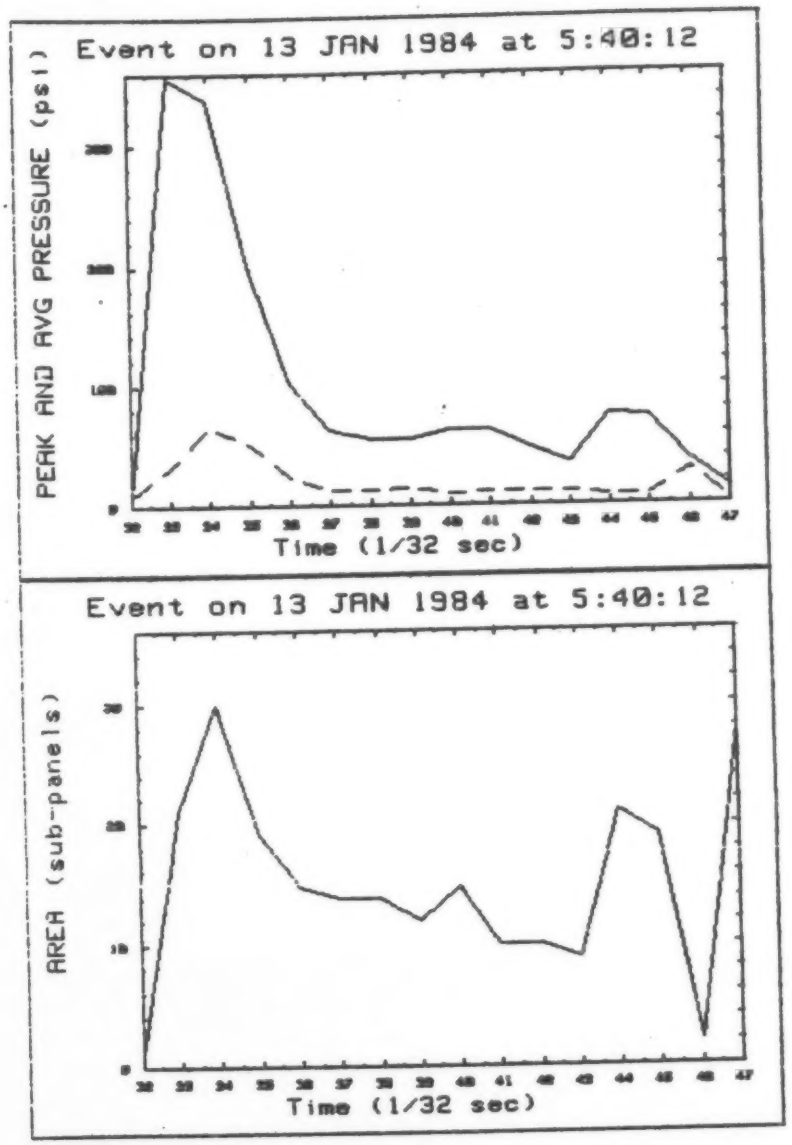

Event ON 13 JAN 1984 at 5:40:12
Total Force (long tons)
Time (seconds)
Event ON 13 JAN 1984 at 5:40:12
Pressure (psi)
1000
100
10
1
10
Area (square feet)


Event on 13 JAN 1984 at 5:40:12
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)


Event on 13 JAN 1984 at 5:40:12
AREA (sub-panels)
Time (1/32 sec)


Event on 13 JAN 1984 at 5:40:12
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)


Event on 13 JAN 1984 at 5:40:12
AREA (sub-panels)
Time (1/32 sec)


Event on 13 JAN 1984 at 5:40:12
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 13 JAN 1984 at 5:40:12
AREA (sub-panels)
Time (1/32 sec)